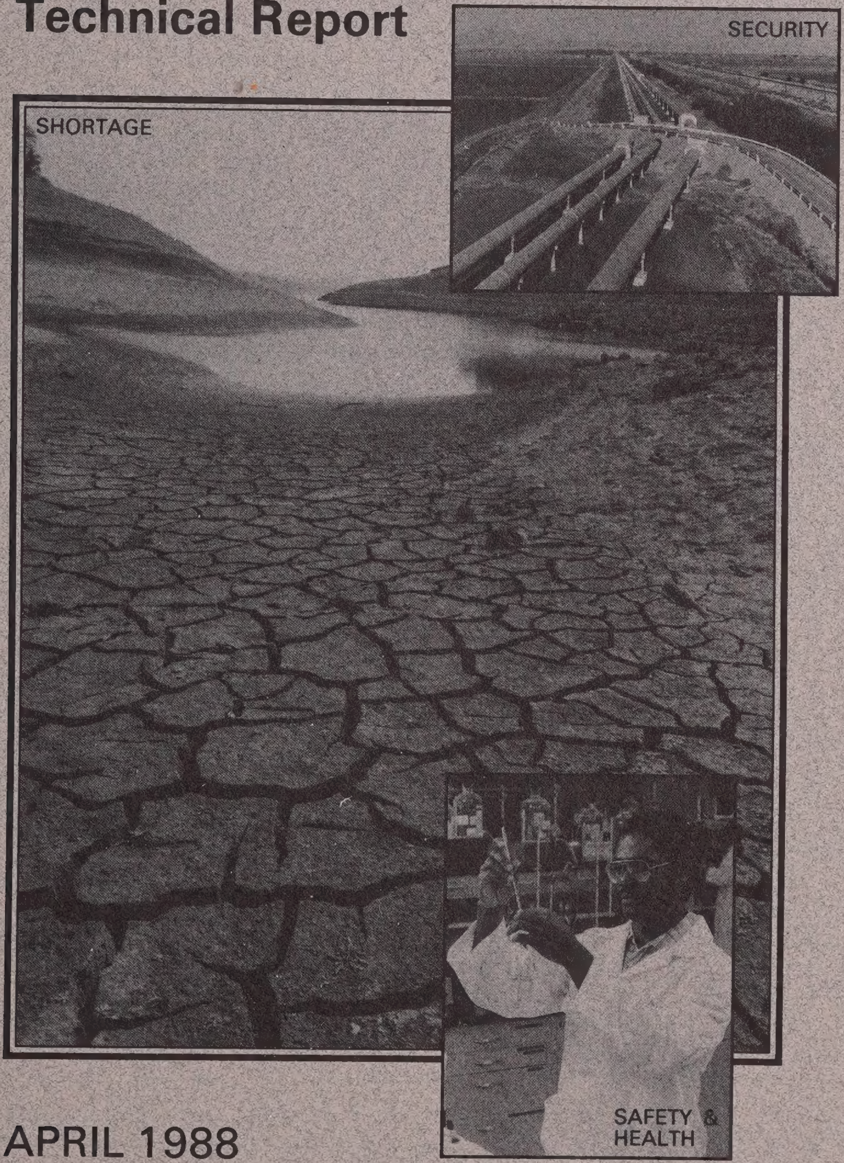
WATER SUPPLY MANAGEMENT PROGRAM

Technical Report



APRIL 1988

East Bay Municipal Utility District

EBMUD

WATER SUPPLY MANAGEMENT PROGRAM

TECHNICAL REPORT

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PREFACE

In February of 1987, EBMUD staff prepared a discussion paper to initiate the public review and input process on the scope and content of the Water Supply Management Program and related Environmental Impact Report. On March 17, 1987, EBMUD staff conducted a public meeting to discuss and solicit comments on the discussion paper. This technical report discusses the water supply issues and problems facing EBMUD customers and based on investigations and studies, identifies and evaluates alternative solutions to these problems. The economic impacts of the costs of the proposed projects are also included in this report. A draft Environmental Impact Report (EIR) and a Summary document covering both the technical report and EIR have also been prepared in conjunction with this technical report.

WATER SUPPLY MANAGEMENT PROGRAM

TECHNICAL REPORT

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Chapter I
Introduction

PURPOSE OF REPORT

East Bay Municipal Utility District (EBMUD) is facing several major water supply problems. The major problems are an increasing risk of failure of the Mokelumne Aqueducts, an increasing frequency of shortage in dry periods, and maintenance of high quality drinking water.

The Water Supply Management Program identifies the actions and projects necessary to solve these problems and discusses the technical and economic feasibility of various alternative actions and projects. The report presents the elements for the District's Water Supply Management Program and provides the basis for preparation of the environmental impact report.

ACTION BY EBMUD

Public Briefings by EBMUD Staff

In addition to the public comment period in 1987 and the public hearings and meetings scheduled for this spring, EBMUD staff has made a concerted effort to brief agencies and organizations on the key issues and needs and to respond to different viewpoints about the program.

The District will make the draft of this report and the accompanying Draft Environmental Impact Report (DEIR) available for public review and will hold a public meeting on May 18, 1988 and a public hearing on May 25, 1988. This report and the DEIR will then be modified, where appropriate, to incorporate comments received from the public, interested organizations and other agencies. The final report and EIR will be submitted to the EBMUD Board of Directors for approval in July 1988.

The EBMUD Board of Directors will formally consider the projects and the EIR for the Water Supply Management Program. The following actions will be recommended to the Board:

1. Accept the technical report.

2. Certify that the Final EIR has been completed in compliance with the California Environmental Quality Act (CEQA) for all near-term projects.

3. Adopt the Water Supply Management Program and authorize the continuation of the projects proposed for the program:

   - Water Supply Objectives
   - Program Elements
   - Specific Projects and Actions

Future Action

Construction of any facilities approved as part of the program could require an additional sequence of actions, such as the following:

- Additional geotechnical investigation.

- Field testing of conservation techniques and pilot tests.

- Application to the Corps of Engineers for a permit under Section 404 of the Clean Water Act.

- Coordination with cities, counties, and other agencies regarding the impacts of construction and construction traffic.

- Design of the facilities and preparation of plans and specifications.

- Competitive bidding and award of construction contracts.

WATER SUPPLY OBJECTIVES

EBMUD's water supply problems and needs focus on three basic issues — security, shortage, and safety and health. These issues establish the objectives for development of the Water Supply Management Program:

SECURITY: Provide security of the water supply against delivery system outages caused by floods and earthquakes.

SHORTAGE: Provide an adequate water supply to meet dry year demands.

SAFETY AND HEALTH: Maintain a standard of high water quality.

DISTRICT BACKGROUND

Service Area

EBMUD supplies water to approximately 1.1 million people. The service area covers 310 square miles and includes twenty cities and sixteen communities in portions of Alameda and Contra Costa Counties.

The 20 cities served by EBMUD's Water System include Alameda, Albany, Berkeley, Danville, El Cerrito, Emeryville, a portion of Hayward, Hercules, Lafayette, Moraga, Oakland, Orinda, Piedmont, Pinole, a portion of Pleasant Hill, Richmond, San Leandro, San Pablo, San Ramon, and a portion of Walnut Creek. Brentwood is served water by contract.

Unincorporated communities served include Alamo, Ashland, Blackhawk, Castro Valley, Cherryland, Crockett, Diablo, El Sobrante, Fairview, Kensington, North Richmond, Oleum, Port Costa, Rodeo, San Lorenzo and Selby.

Water Supply System

The Water Supply System includes a network of reservoirs, aqueducts, treatment plants, and other distribution facilities stretching from the Sierra foothills to the Bay Area. Figure I-1 is a location map of the District's major water supply facilities. These facilities include:

- Pardee and Camanche Reservoirs on the Mokelumne River.
- Three parallel aqueducts between Pardee Reservoir and Walnut Creek.
- Local raw water aqueducts and pumping plants between Walnut Creek and various terminal reservoirs and filter plants.
- Three major local terminal reservoirs.
- Six filter plants.

Sources of Supply

MOKELUMNE RIVER

The District holds two water rights (License 11109 and Permit 10478), which together entitle it to divert up to 325 MGD from the Mokelumne River at Pardee Reservoir and put this water to use in portions of Alameda and Contra Costa Counties for municipal and industrial purposes. The District's entitlement to the Mokelumne River is available after the water needs of more senior right-holders have been met. Further details regarding the District's Mokelumne water rights may be found in EBMUD's Urban Water Management Plan (1985).

TERMINAL RESERVOIRS

In normal years, District reservoirs in the East Bay receive an additional 10 billion gallons of water from local watershed runoff. Much of it is captured for system use. In dry years, evaporation and other reservoir losses can exceed runoff, so there is no firm yield from local watersheds. The following sections describe the key features of the Water Supply System, starting nearest the source of supply.

BUREAU OF RECLAMATION CONTRACT

In 1970, the District contracted with the U.S. Bureau of Reclamation (USBR) for a supplemental supply of American River water from the Central Valley Project (CVP). The contract is for 150,000 acre-feet annually (AFA), or about 134 MGD. This amount, however, can be reduced by the USBR in drought years according to the contract and estimates of available CVP water supply by the USBR and Department of Water Resources (DWR). The point of delivery is on the Folsom South Canal near Grant Line Road, about 12 miles south of the American River. The aqueduct system necessary to convey water from the canal to the EBMUD service area is the District's responsibility, and such facilities have not yet been constructed.

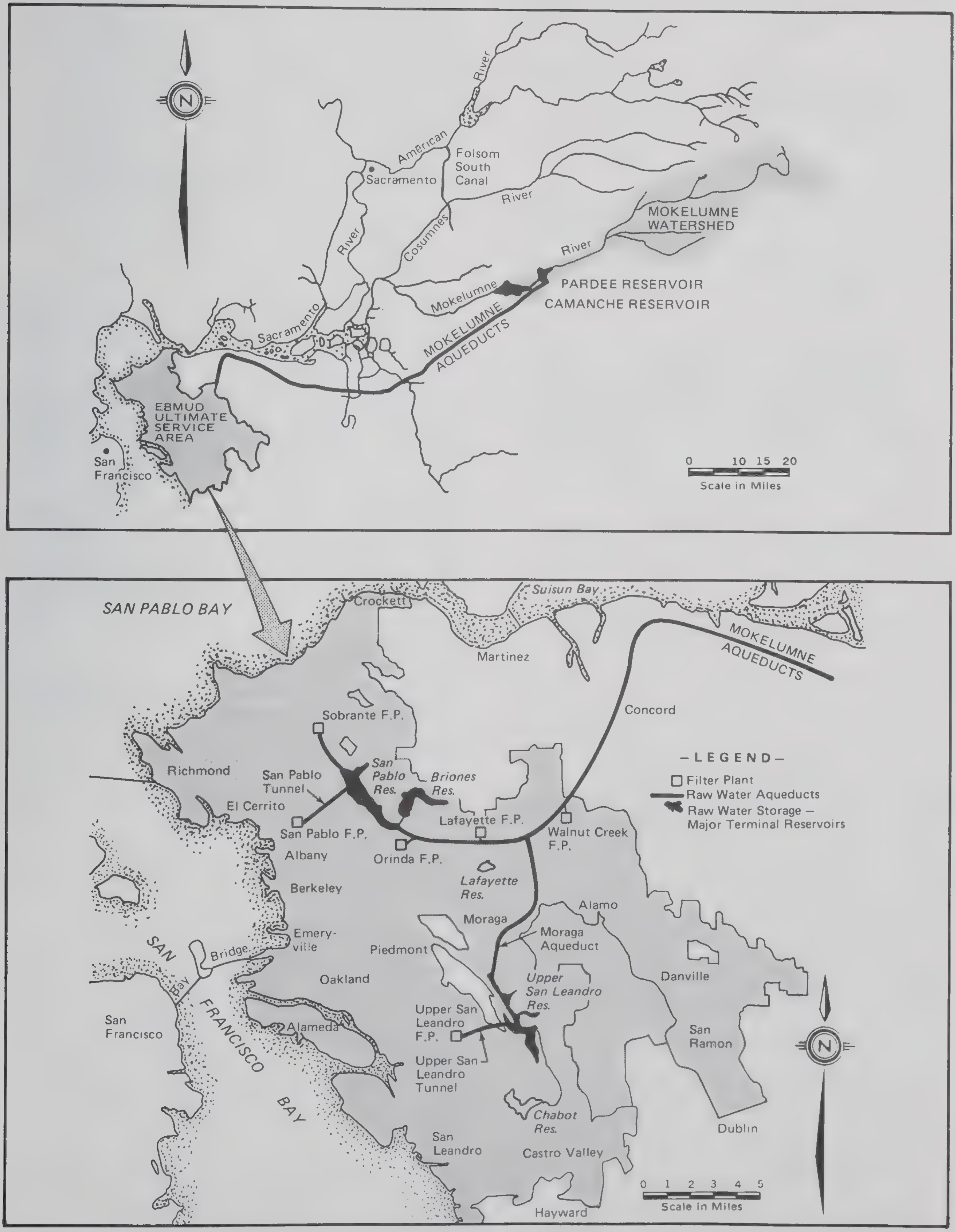
Storage - Mokelumne River

PARDEE DAM

Pardee Dam is located 38 miles northeast of Stockton on the Mokelumne River. The concrete gravity arch structure was completed in 1929 and rises 345 feet above the riverbed. The roadway across the dam is 575 feet above sea level and the top of the gatehouse is 598 feet above sea level. The dam is 16 thick at its

EBMUD Water Supply Facilities

Figure I-1



crest and 239 feet thick at its base. Approximately 617,000 cubic yards of concrete were used in construction of the dam.

A 28.65 megawatt power plant at the dam generates approximately 110 million kilowatt hours per year for sale to Pacific Gas and Electric Company.

PARDEE RESERVOIR

Pardee Reservoir, with a capacity of 210,000 acre-feet and surface area of 2,257 acres, provides storage for municipal water supply and power generation.

CAMANCHE DAM

Camanche Dam, a zoned gravel structure with an impervious core, is located about 10 miles downstream from Pardee Dam on the Mokelumne River. Completed in 1964, it rises 171 feet above the riverbed and 263 feet above sea level. The spillway is 235.5 feet above sea level. The length of the crest is 2,640 feet and the dam is 34.5 feet thick at the crest and 750 feet thick at the base.

The dam and four miles of dikes contain 11.1 million cubic yards of material.

A 10.68 megawatt power plant at the dam generates approximately 40 million kilowatt hours per year for sale to Pacific Gas and Electric Company.

CAMANCHE RESERVOIR

Camanche Reservoir, with a capacity of 430,000 acre-feet and a surface area of 7,622 acres, provides storage for irrigation, streamflow regulation, flood control, power generation, and meeting the needs of other water rights holders. This allows EBMUD to take its full allocation out of Pardee Reservoir.

Storage - Terminal Reservoirs

In the East Bay Hills, the District owns and operates three major terminal reservoirs: Upper San Leandro, San Pablo, and Briones. Total capacity of all the reservoirs is 155,000 acre-feet. The actual usable storage capacity is 137,500 acre-feet.

MAJOR OPERATING RESERVOIRS

- Upper San Leandro — 41,400 acre-feet
- San Pablo — 38,600 acre-feet
- Briones — 60,500 acre-feet

STANDBY STORAGE

- Chabot — 10,300 acre-feet
- Lafayette — 4,200 acre-feet

Raw Water Aqueduct and Tunnels

Water from Pardee Reservoir moves through a tunnel about 2 miles long to the start of three Mokelumne Aqueducts at Campo Seco Center for transmission to the East Bay. All three aqueducts are steel pipelines extending about 82 miles from Pardee tunnel to the east end of the Lafayette Aqueducts in Walnut Creek. The aqueducts can deliver up to 200 MGD by gravity and up to 325 MGD by pumping. Aqueduct sizes are:

- Aqueduct No. 1 — 65 inches diameter
- Aqueduct No. 2 — 67 inches diameter
- Aqueduct No. 3 — 87 inches diameter

Lafayette Aqueduct No. 1 consists of a 9-foot circular concrete pipe and three tunnels. It extends 7.06 miles from Walnut Creek to the Orinda Filter Plant. Lafayette Aqueduct No. 2 is a 9-foot concrete pipe with seven tunnels. It extends 7.29 miles to the Briones Diversion Works near Orinda. Here the supply can be pumped through the 7 foot-6 inch steel Briones Aqueduct into Briones Reservoir, discharged into San Pablo Reservoir, or diverted through the 7 foot-6 inch steel Orinda Raw Water Line to Orinda Filter Plant in the event the Lafayette No. 1 Aqueduct is out of service. Either or both Lafayette Aqueducts can be diverted in part at Lafayette Center to supply directly or indirectly all filter plants of the District.

Water Treatment Plants

Water delivered to customers must pass through one of EBMUD's six operating filter plants. The total filter plant capacity is 502 MGD.

- Orinda — 175 MGD
- Walnut Creek — 75 MGD
- Upper San Leandro — 83 MGD
- San Pablo — 60 MGD
- Sobrante — 60 MGD
- Lafayette — 42 MGD

Orinda, Lafayette, and Walnut Creek Filter Plants normally receive water directly from the Mokelumne Aqueducts, although they may receive raw water from Briones and Lafayette Reservoirs. Mokelumne water is of very high quality, so these plants usually provide only filtration, chlorination, and fluoridation. The other three plants normally receive raw water from the terminal reservoirs. These plants therefore also provide the pre-filtration steps of aeration, flocculation, and sedimentation.

Filter plant washwater is no longer routinely discharged to streams. Instead, it is reclaimed to comply with waste discharge requirements of the San Francisco Regional Water Quality Control Board,

saving up to 2 MGD of water used in treatment operations. Permanent facilities have been completed at Sobrante, Upper San Leandro and Walnut Creek Plants and temporary facilities have been constructed at Lafayette and San Pablo Filter Plants pending completion of permanent reclamation units.

Land Use

The Utility District owns approximately 41,841 acres of watershed lands surrounding seven reservoirs with a total water surface of 12,765 acres. This land plays an important role in the protection of water quality.

The Land Use Master Plan adopted in October 1970 determines the use of the land in a manner compatible with its primary purpose as a watershed and with emphasis on preservation of open space.

The Master Plan provides 22,652 acres for watershed management, including grazing, farming and community horse pastures; 12,755 acres for recreation; 5,784 acres for educational uses; and 650 acres for various other purposes.

Recreation

Five reservoirs are open for recreation. Briones and Upper San Leandro are not. Four of the five, Pardee, Lafayette, Chabot and San Pablo Reservoirs, store drinking water, so swimming, waterskiing, wading and similar body contact activities are not permitted. Camanche, a flood control and irrigation reservoir, is not used as a source of domestic water supply, so body contact sports are permitted there.

Pardee Reservoir was opened to the public in 1958. Lafayette, Chabot and Camanche were opened in 1966 and San Pablo in 1973.

Lafayette Reservoir is a day-use area and remains open all year. Rental rowboats, pedal boats and electric boats are available. Canoes, kayaks and small "car-top" private sailboats are allowed, but no gasoline motors are permitted. Public as well as group facilities are available on a limited basis.

Chabot Reservoir also is open all year and has facilities for boat and bank fishing, canoeing, picnicking and hiking. It is operated by the East Bay Regional Park District under a 32-year agreement that expires in 1998.

San Pablo Reservoir is open daily from mid-February to mid-November. Activities operated by a private concessionaire include excellent fishing, picnicking, boating (25 mph maximum speed) and hiking. Group picnic areas are available, as are rental rowboats, canoes and motorboats.

Since 1974, approximately 80 miles of hiking and horse-riding trails have been opened for public permit use through the East Bay watershed lands. Trail users must have valid trail permits which are available for a nominal fee at EBMUD business offices and recreation areas.

Camanche Reservoir is open all year and includes a wide variety of facilities for day and overnight use at two locations on the north and south shores. These recreation facilities are operated by private concessionaires responsible to the Camanche Regional Park Board, which leases the reservoir and most of the surrounding lands from the District. The Park Board was established in 1964 by a Joint Powers Agreements with the three host counties - Amador, Calaveras and San Joaquin - which have lease agreements with concessionaires.

Pardee Reservoir Recreation Area is open daily from mid-February to mid-November. Facilities operated by a private concessionaire include a launching ramp, overnight camping, trailer park, picnicking, boat and motor rentals, children's play area, restaurant, bait and tackle shop, and swimming pools.

Chapter II
Security:
Pipe Breaks Due to Floods and Earthquakes

BACKGROUND

Problem

EBMUD's water supply system is subject to damage from earthquakes and floods, which can result in severance of the Mokelumne water supply. The need for increased security of the water supply facilities in the Delta was demonstrated in 1980 when Lower and Upper Jones Tracts flooded. Although the aqueducts were not damaged, the soil surrounding the support structures was partially washed away. EBMUD has studied various types of potential failures and the associated levels of risk to the water supply facilities. A review of the vulnerable areas of the raw water supply system identifies the Delta as the most critical area. There is a need to protect against extended outages caused by flood or earthquake damage in the Delta and a need to reduce the severity of rationing during an extended outage.

EBMUD System

The source of nearly all of EBMUD's water supply is the watershed of the Mokelumne River. As shown in Figure II-1, water is stored at Pardee Reservoir before it is transported to the District's service area where it can be stored in terminal reservoirs or directly treated. Before reaching the water treatment plants, the water supply system is vulnerable to earthquakes and floods which could result in severance of Mokelumne River supplies.

Areas studied in this chapter include the Mokelumne River facilities at Pardee, the local water system in the service area, and a sixteen mile long section of the Mokelumne Aqueducts crossing the Sacramento-San Joaquin Delta. Severance of supply could cause severe water rationing for the District's customers. Figure II-2 summarizes the problems in the water supply system. There are several alternatives, as discussed in the following sections, to reduce the vulnerability of the raw water supply to outages.

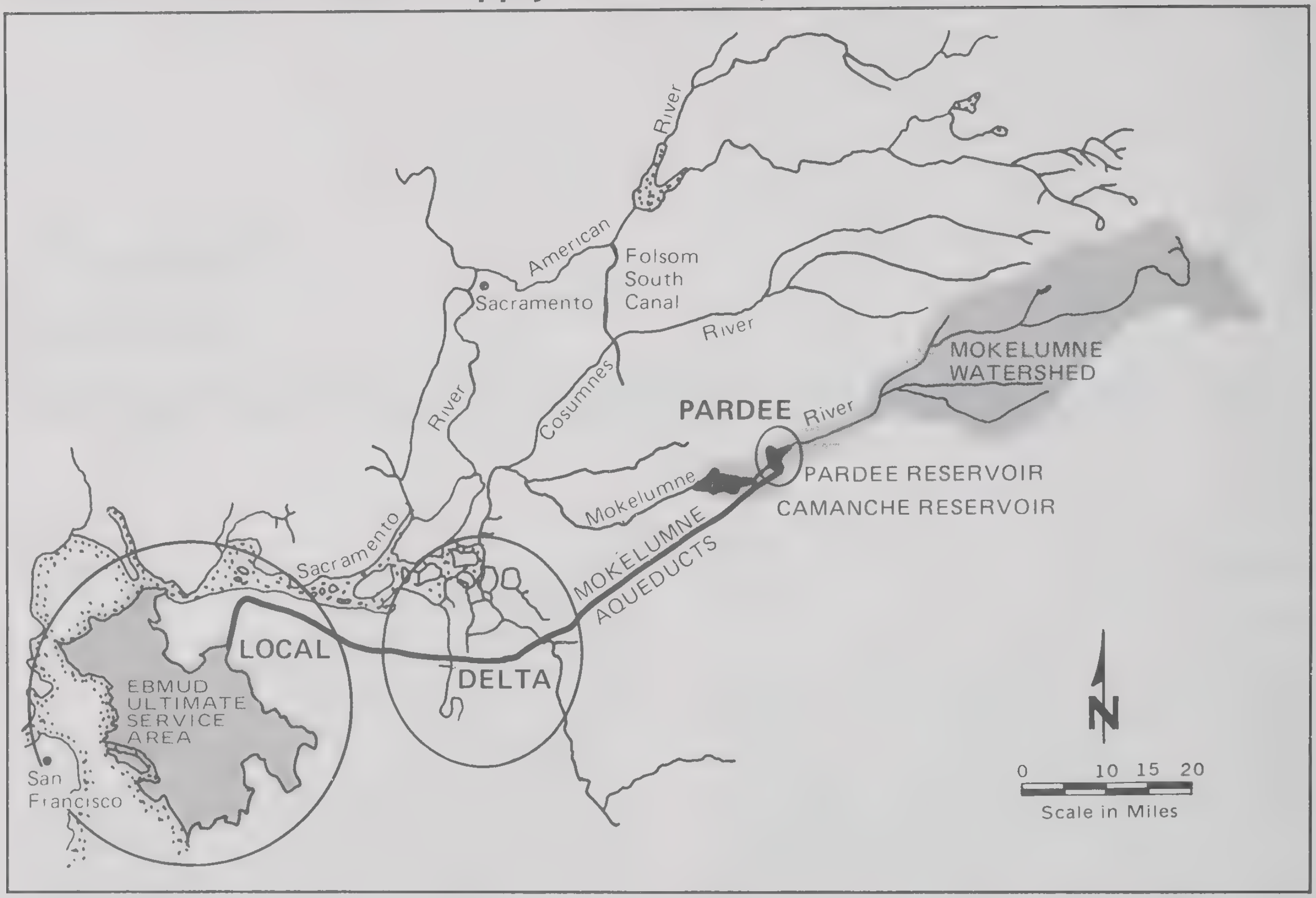
This chapter focuses on security alternatives, such as water banking (additional terminal storage to provide water during an outage); foundation improvements in the Delta, including preliminary engineering for the design of a future aqueduct; a new aqueduct across the Delta; interties with other agencies; and possible groundwater resources. The best apparent alternatives will be further evaluated in Chapter V.

Mokelumne River Facilities at Pardee

The Mokelumne River facilities at Pardee are critical to the water supply system since all of the water from the Mokelumne River is stored at Pardee Reservoir (Figure II-3). The Pardee facilities include the reservoir, dam, outlet tower, and tunnel, which are all located within three miles of the Bear Mountain Fault Zone. The Pardee Dam is considered seismically safe and a recent study (Dames & Moore, 1987) concluded that the Pardee outlet tunnel was able to resist the maximum credible earthquake (MCE) from the Bear Mountain Fault. The MCE, defined as the maximum earthquake generated from a fault, was estimated to occur once in every 10,000 years. The study further concluded that Pardee tower could withstand moderate to high ground shaking from the Bear Mountain Fault. Damage at Pardee is not expected to produce severe rationing, and does not pose a problem to the water supply system.

Areas of Potential Water Supply Vulnerability

Figure II-1



Local Water Supply System

The San Andreas, Hayward, and Calaveras faults are active faults that could damage local EBMUD water supply tunnels resulting in outages. The local tunnels cross several inactive faults. While these inactive faults, which have not moved in the last 10,000 years, are not expected to produce an earthquake, they are expected to move during a major earthquake on the nearby active faults (Marliave et al., 1972). Estimates of possible damage and the water supply outage time were made to determine the vulnerability of the local water supply tunnels. The vulnerability of the tunnels is discussed below and the tunnels are shown in Figure II-4.

Studies to estimate the potential earthquake damage and corresponding repair times for various tunnels were performed by Marliave et al., 1972; F.P. Bystrowski & Co., 1972; and Woodward-Lundgren & Associates, 1974. These studies concluded that earthquakes would cause only minor damage to reinforced tunnels constructed in bedrock (Pleasant Hill Tunnels, Walnut Creek Tunnel No. 2, and Lafayette Tunnel No. 2) and that these water supply facilities would remain operational until repairs could be made.

The studies also estimated that earthquakes may cause significant damage to unreinforced and reinforced tunnels constructed in alluvial material (Walnut Creek No.1, Lafayette No.1, San Pablo, and San Leandro Tunnels). Although significant earthquake damage may not cause complete and immediate tunnel closure, the amount of water flow would be restricted.

The amount of damage will depend on the geology and structural adequacy of each tunnel. Estimates of the outage time required for tunnel repairs were based on a 24 hour workday, 7 days per week, from the time of tunnel closure to tunnel restoration. The outage times vary from 30 to 180 days as follows:

- 30 days for Walnut Creek Tunnel No. 1
- 30 days for Walnut Creek Tunnel No. 2
- 180 days for Lafayette Tunnel No. 1
- 60 days for Lafayette Tunnel No. 2
- 30 days for Pleasant Hill Tunnels Nos. 1 & 2
- 120 days for San Pablo Tunnel
- 120 days for San Leandro Tunnel

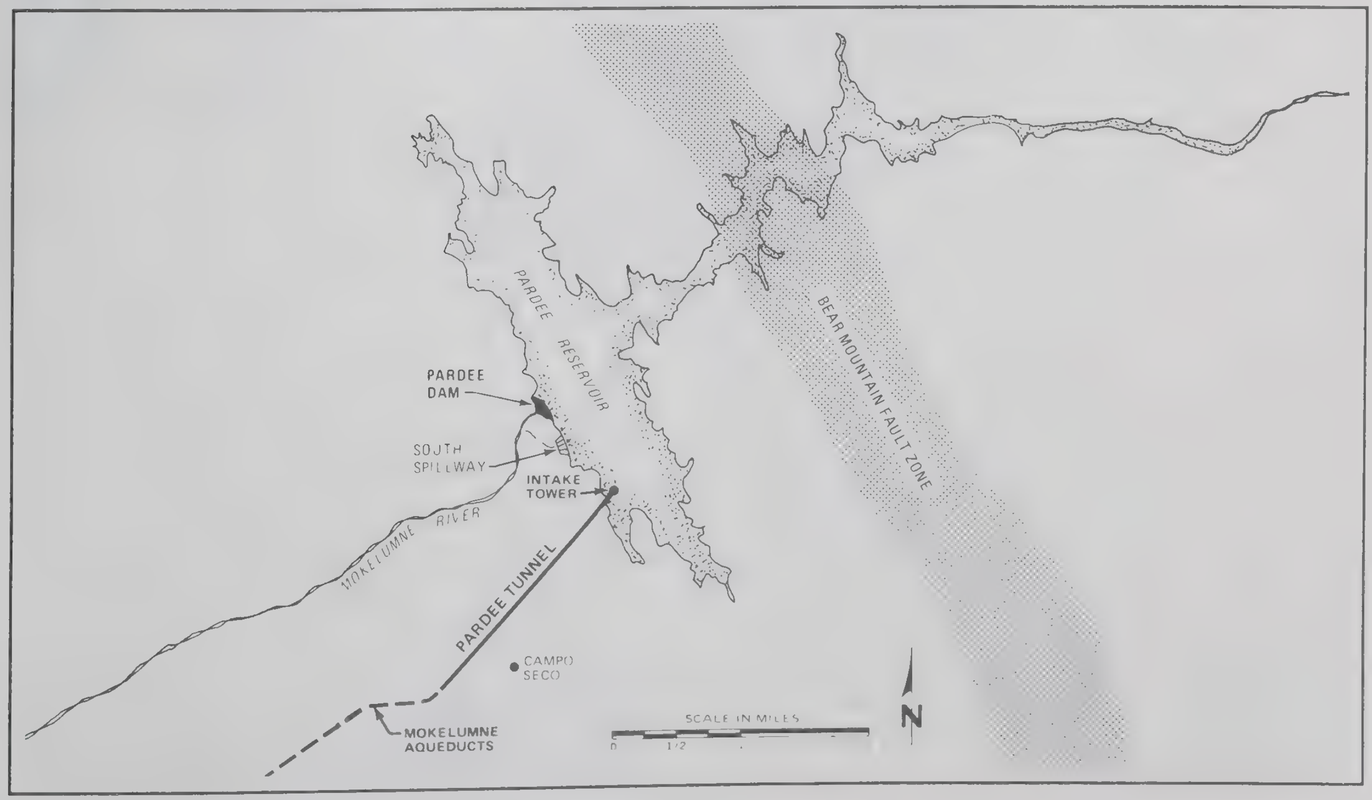
Summary of Potential Problems in the Water Supply System

Figure II-2

	PARDEE DAM	LOCAL RAW WATER SYSTEM (Terminal Reservoirs, Aqueducts and Tunnels)	MOKELUMNE AQUEDUCTS IN THE DELTA
EARTHQUAKES	No damage from earthquakes with recurrence intervals of less than once in 250 years.	Damage may be caused by high to very high ground movement.	**Very high ground shaking:** Extensive levee failure. All Islands and tracts flooded. Entire 16 miles of aqueducts damaged. Salinity up to 2,600 mg/L at Rock Slough.
			High ground shaking: Levee breaks at many locations. More than three islands flooded. Elevated Aqueduct #1 destroyed Four miles each of Aqueducts #2 & 3 damaged. Salinity up to 2,600 mg/L at Rock Slough.
		Damage unlikely due to low to moderate ground movement.	**Low/moderate ground shaking:** Levee breaks at several locations. One or more islands flooded. Elevated Aqueduct #1 extensively damaged. Up to 2 miles each of Aqueducts #2 & 3 damaged. Salinity up to 1,000 mg/L at Rock Slough.
FLOODS	No damage due to floods	Damage unlikely due to floods.	**Flood due to overtopping and instability:** Scour from flow through break undermines piles. All aqueducts next to break scour damaged. Up to 750' of each aqueduct damaged. One or more islands or tracts flooded. Salinity up to 2,600 mg/L at Rock Slough.

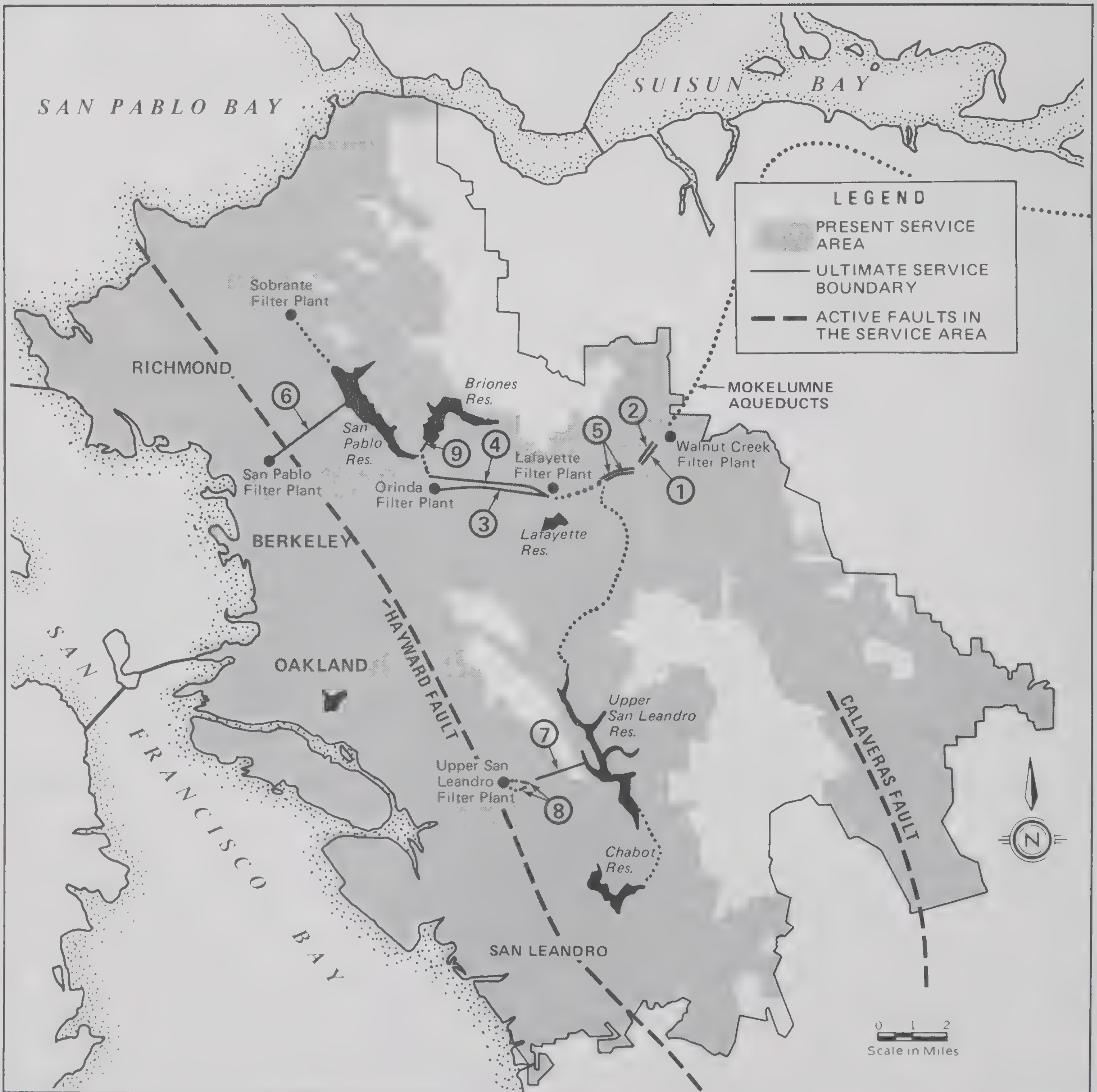
Pardee Reservoir

Figure II-3



Water Supply Tunnels in the Local Service Area

Figure II-4



WATER SUPPLY TUNNELS

(1) Walnut Creek Tunnel No. 1	(4) Lafayette Tunnel No. 2	(7) Upper San Leandro Tunnel
(2) Walnut Creek Tunnel No. 2	(5) Pleasant Hill Tunnels Nos. 1 & 2	(8) Oak Knoll Tunnels
(3) Lafayette Tunnel No. 1	(6) San Pablo Tunnel	(9) Briones Tunnel

- 90 days for Oak Knoll Tunnels (between San Leandro Tunnel and San Leandro Filter Plant)
- 180 days for Briones Tunnel.

Terminal reservoirs provide standby storage in case of such an outage. EBMUD currently tries to maintain a minimum of 120 days of standby supply to be able to respond to short-term supply disruptions. The 120-day

supply is based on the time needed to repair potential tunnel outages and is required as standby for a third year drought.

The raw water tunnels from the terminal reservoirs to the water treatment plants are also susceptible to outages. Although closure of a reservoir outlet tunnel could isolate the terminal reservoir, areas normally served by an isolated reservoir can still be served by another reservoir. For example, the area served by Upper San Leandro Reservoir can also be served by Briones Reservoir in the event of damage to the Upper San Leandro or Oak Knoll Tunnels. In the event of damage to the San Pablo Tunnel, customers served by San Pablo Reservoir can still be served by the Sobrante Filter Plant. In summary, the District maintains a 120-day standby supply to meet short-term outages in the local raw water supply system.

EBMUD's existing dams in the service area have recently been evaluated by independent consultants and subsequently modified to resist maximum credible earthquakes to meet the California Division of Safety of Dams safety requirements. Any new dam would be designed to meet the latest safety standards which currently require a dam to withstand a maximum credible earthquake.

Delta

The Sacramento-San Joaquin Delta (Delta) comprises about 750,000 acres with more than 60 islands and tracts formed by 1,100 miles of levees. The tributary rivers and streams supply fresh water that passes through 600 miles of waterways and eventually out of the Delta. The fresh water pushes back the sea water from Suisun Bay. As shown in Figure II-5, the Sacramento River enters the Delta from the north and the San Joaquin River enters from the south and divides into three channels within the Delta: the San Joaquin, Old, and Middle Rivers. Rivers entering from the east include the Mokelumne, Calaveras, and Cosumnes. Exports of Delta water for municipal, industrial, and agricultural usage include: flows to South San Francisco Bay, Southern California and San Joaquin Valley via the state's Harvey O. Banks (Delta) Pumping Plant and the federal Tracy Pumping Plant, both located at the southern end of the Delta; and flows to the Contra Costa Water District (CCWD) service area via CCWD's pumping plant at Rock Slough located in the western end of the Delta.

In terms of EBMUD's water supply system, the Delta is the most critical area because floods and earthquakes could cause severe water supply outages. The Delta is comprised of an extensive system of levees, which are not designed to resist major flooding and earthquake forces. Levee failure and subsequent flooding could lead to aqueduct damage. Furthermore, Delta water quality can be severely degraded during the flooding of an island, making the Delta unreliable as a source of emergency water. This section reviews potential risks to EBMUD facilities in the Delta, provides background information relating to the Mokelumne Aqueducts, and discusses the involvement by EBMUD, state, and federal agencies to improve the levees and the quality of Delta water.

POTENTIAL RISKS TO EBMUD FACILITIES IN THE DELTA

The need for increased security for EBMUD water supply facilities in the Delta was made clear in 1980 when Lower and Upper Jones Tracts flooded. The railroad embankment adjacent to the Mokelumne Aqueducts subsequently failed, allowing flood waters to flow into Upper Jones Tract, inundating the tract crossed by more than 5 miles of the aqueducts, as shown in Figures II-6 and II-7.

Although the pipelines did not break, there was deep scour, which almost undermined the pipes' support structures. Two fortuitous circumstances contributed to the survival of the pipelines: The flow through the break was reduced by the low water level on Lower Jones Tract and was deflected by two locomotives and a box car that fell off the railroad embankment.

The 1980 flood accelerated EBMUD studies and investigations of the types of potential aqueduct failures and associated levels of risk of various magnitude earthquakes and potential Delta levee failures caused by floods. The results of these investigations are described in later sections of this chapter.

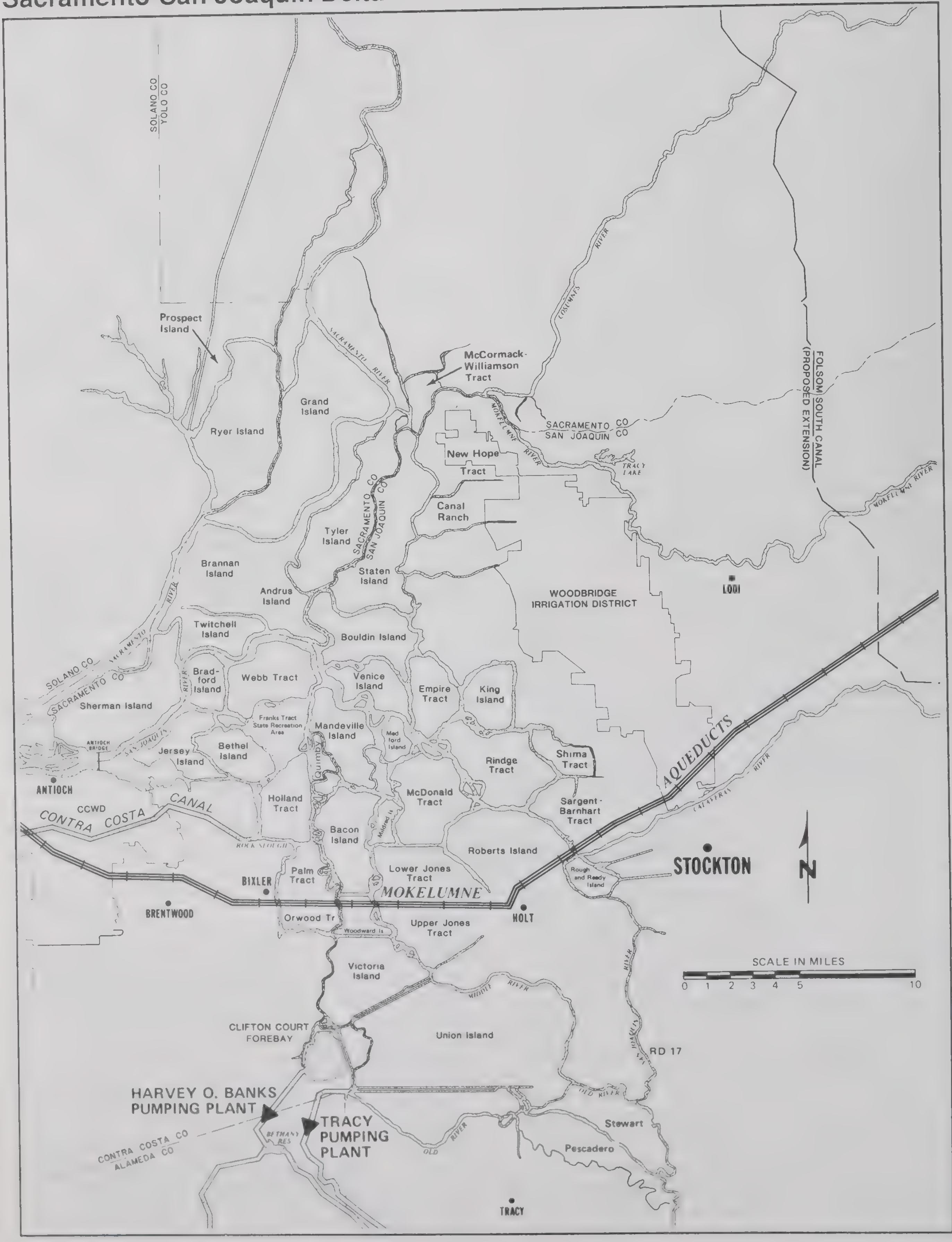
THE MOKELUMNE AQUEDUCTS IN THE DELTA

The Mokelumne Aqueducts were not designed to resist flooding or earthquake forces in the Delta. Severe damage may occur with long durations of water supply outage. This section discusses the inadequate support structure of the aqueducts and soil conditions in the Delta.

The Mokelumne Aqueduct system crosses the Delta in three parallel pipelines. Aqueducts Nos. 1,2, and 3 were constructed in 1928, 1949, and 1963 with inside diameters of 65, 67, and 87 inches, respectively. Aqueduct No. 1 is supported by concrete bents on wood piles and Nos. 2 and 3 by steel bents on concrete piles.

Sacramento-San Joaquin Delta

Figure II-5

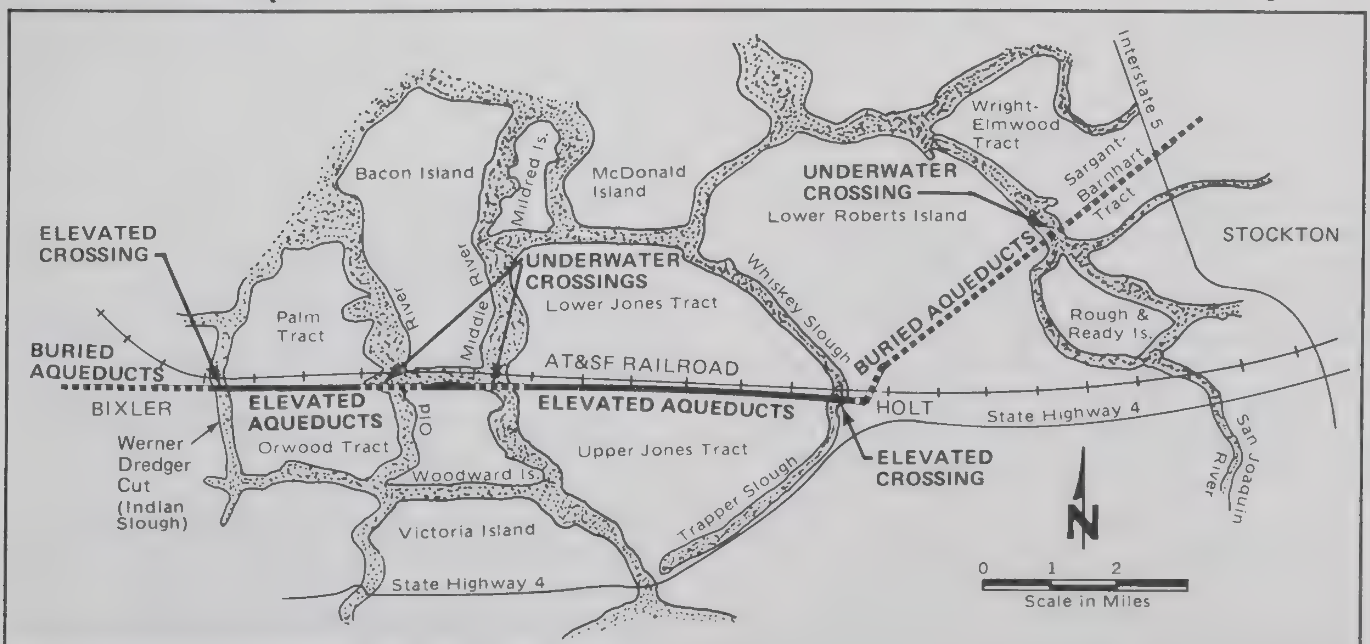


1980 Upper Jones Tract Flood

Figure II-6

Mokelumne Aqueducts Across the Delta

Figure II-7



The aqueducts enter the vulnerable portion of the Delta west of the City of Stockton, about 3,000 feet west of Interstate Highway 5 (on Sargent-Barnhart Tract), and exit the Delta 2,000 feet west of Indian Slough (on Upper Orwood Tract), as shown in Figure II-7. The Mokelumne Aqueducts cross about 16 miles of the Delta, with about 60 percent elevated and the remaining 40 percent buried including three underwater crossings, as indicated in Figure II-8.

Aqueduct Support Structure. The support systems for the elevated aqueduct sections are shown schematically in Figure II-9. The piles of Aqueduct No. 1's support are not able to resist even moderate earthquake forces. The tops of the untreated wooden piles have suffered serious decay. Furthermore, the pin connection between the concrete bents and the timber cradles of Aqueduct No. 1 is inadequate to support the pipeline during low to moderate ground shaking. The support system for the elevated portions of Aqueducts Nos. 2 and 3 have a sling and steel frame bent structure which provides the pipelines with adequate support during low to moderate ground shaking. However, none of the aqueducts are attached to their supports and could float free if submerged in a flood.

Sections of the aqueducts in the Delta are buried. Both the elevated and buried portions of the aqueducts are susceptible to damage as a result of levee failure from earthquakes and floods.

Existing Levees. Figure II-10 illustrates the cross-section of a typical levee. The islands in the Delta all have ground surface elevations below mean sea level and are protected from flooding by levees. These levees are typically not engineered embankments, but are simply composed of fill dredged from adjacent channels and piled along the sides.

Foundation soil for both the levees and the aqueduct pipelines are composed of peat and loose sandy silt. The weak and highly compressible fibrous organic peat is the primary reason for levee settlement and the main cause of overall settlement of the entire central Delta region. The continued settlement of the Delta islands has increased the risk of levee failures and has made levee integrity vital to the operation of the Mokelumne Aqueducts. Loose sands, also located in the foundation soil, are vulnerable to earthquake-induced liquefaction (a quick-sand condition) that could result in support failure for levees and pipelines.

PAST IMPROVEMENTS IN THE DELTA

To reduce the likelihood of severe rationing and economic impact to EBMUD customers during an outage, the District has implemented several measures to improve the security of the aqueducts. These measures followed the near failure of the Mokelumne Aqueducts during the Lower Jones Tract levee and railroad embankment failures in 1980 and include levee inspection and monitoring ($0.9 million, 1982-1987), stockpiling of aqueduct pipes ($0.6 million, 1982), and assistance to island reclamation districts for levee improvements ($1.3 million, 1981-1987). Although EBMUD has no direct authority over the Delta levees, it voluntarily monitors and regularly inspects levees protecting the aqueducts, especially during periods of high tidal stages or flood flows.

The District has purchased 1,500 feet of aqueduct pipe and fittings. The materials are stockpiled at Bixler to permit quick repair of the failed aqueduct sections in the Delta. Damage to the aqueducts due to moderate ground shaking will require miles of pipeline, much more than the amount of stockpiled pipe for minor repairs. Stockpiling additional pipeline would not reduce the time required to repair massive earthquake damage to the aqueducts, because the fabrication and delivery of pipe is not on the critical path to the repair time of the aqueducts.

To reduce the risks of levee failure on the islands along or adjacent to the aqueduct alignment, the District has given financial assistance to the reclamation districts on Woodward Island, Orwood Tract, and Upper Jones Tract to widen and raise the levee crest. The expenditures have been shared by EBMUD and the reclamation districts. The State reimburses portions of the expenditures to the reclamation districts for further levee maintenance and improvements. Beginning in the fiscal year 1981-1982 and ending in fiscal year 1986-1987, the expenditures for levee repairs (before reimbursements) are shown in Figure II-11.

OUTSIDE AGENCY INVOLVEMENT IN DELTA RECLAMATION

Past studies by state and federal agencies were made to improve levee integrity and water quality in the Delta. Both the U.S. Bureau of Reclamation (USBR) and the Department of Water Resources (DWR) depend on the integrity of the Delta levees to insure the export of acceptable quality water. The following sections will discuss the studies.

California's Department of Water Resources Recommendations. A recent study (DWR, 1986) recommended a course of action in the event of a Lower Jones Tract flooding with damage to the Mokelumne Aqueducts. The study recommended that

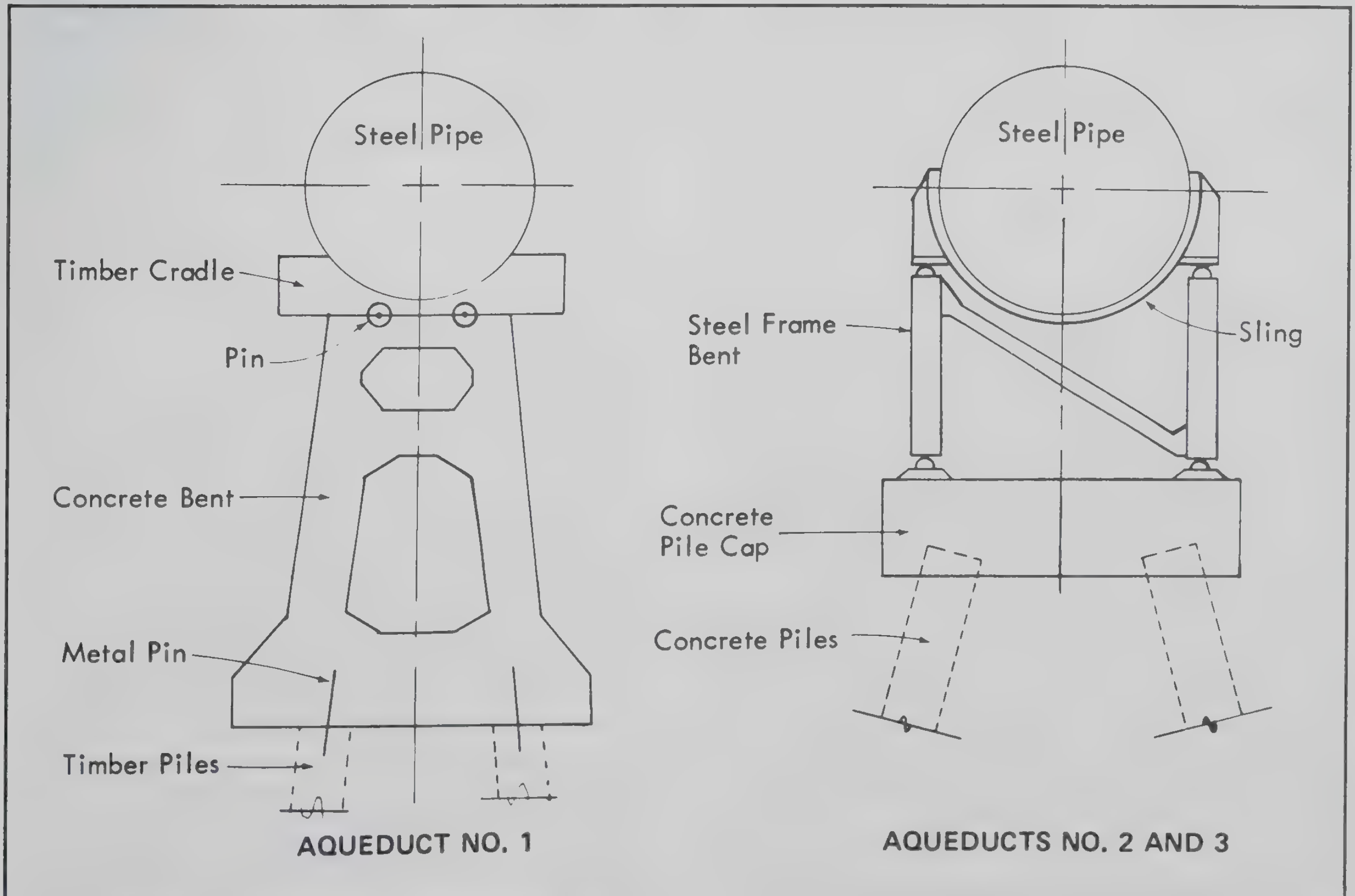
Mokelumne Aqueducts in the Delta Area

Figure II-8

REACH	CONFIGURATION LENGTH, MILES			
	ELEVATED	BURIED	UNDERWATER CROSSING	TOTAL
Sargent-Barnhart Tract	0.0	1.3		1.3
San Joaquin River			0.2	0.2
Lower Roberts Island	0.6	3.5		4.1
Trapper Slough	0.3	0.0		0.3
Upper Jones Tract	5.0	0.2		5.2
Middle River			0.2	0.2
Woodward Island	1.1	0.4		1.5
Old River			0.1	0.1
Orwood Tract	2.3	0.3		2.6
Upper Orwood Tract	0.1	0.3		0.4
TOTAL	9.4	6.0	0.5	15.9

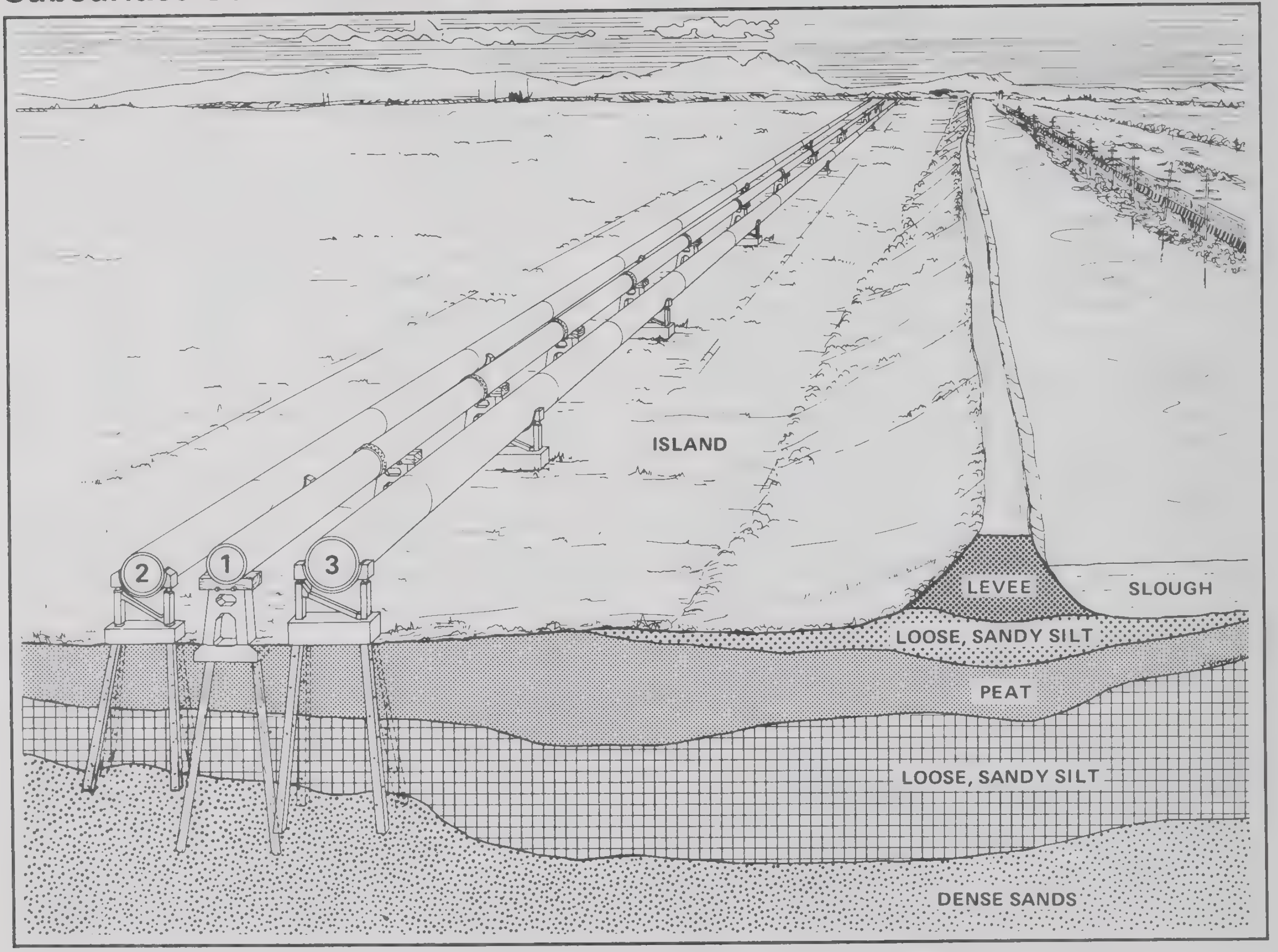
Elevated Aqueduct Supports

Figure II-9



Subsurface Soil Horizons in the Delta

Figure II-10



Levee Repairs and Improvements (1981 to 1987)

Figure II-11

LOCATION	EBMUD* ($ Millions)	RECLAMATION DISTRICTS** ($ Millions)
Woodward Island	0.8	1.2
Orwood Tract	0.3	0.4
Upper Jones Tract	0.2	0.3
TOTAL	1.3	1.9

*Reflects expenditures for improvements made on Delta islands/tracts crossed by the Mokelumne Aqueducts.
**State reimbursement of $0.7 million has been spent on levee improvements.

export of water at the Delta and Tracy Pumping Plants be halted or reduced; upstream releases be increased to augment the freshwater flow into the Delta; and emergency interconnections from other water agencies be established to provide EBMUD with water supplies. The study did not determine if sufficient water supplies with adequate water quality would be available if an outage were to occur.

Interagency Delta Management Committee. Two recent studies of the Delta, (U.S. Corps of Engineers, COE, 1982) (DWR, 1982) identified serious levee problems and recommended various levels of improvements. These studies concluded that two islands crossed by the Mokelumne Aqueducts, Upper Orwood and Woodward Islands, have a high probability of levee failure. The improvements to the levees since the studies have reduced the risks of flooding.

Emergency Delta Task Force. In January 1982, the State Assembly created an advisory panel, the Emergency Delta Task Force, to: propose a levee restoration plan for non-project levees; develop a cost sharing formula, and review the COE and DWR plans for Delta levee restoration. The Task Force recommended immediate erosion protection for Woodward, Lower and Upper Jones, and Lower, Middle and Upper Roberts Islands and immediate major structural improvements for Woodward Island. The Task Force also recommended erosion protection and major structural improvements for Jones, Roberts, Orwood, and Sargent-Barnhart Islands within the next 10 years. The proposed plan was estimated to cost about $35 million in 1982 prices.

Way-Mobley Act. In 1973 the State Legislature enacted the Way-Mobley Act, which established a program to assist Delta levee districts with levee restoration. The funding for this program has been about $2 million per year. In 1988, legislation (SB 34, Boatwright) increased this to $12 million per year for the next 10 years.

PRESENT AND FUTURE NEEDS

Damages to the Mokelumne Aqueducts in the Delta from earthquakes or flooding could result in a complete outage of the Mokelumne water supply for an extended period, which will be discussed in the Risk of System Failure section of this chapter. EBMUD customers could experience adverse impacts of severe water rationing caused by extended outages and the lack of adequate storage. EBMUD has established measures to respond to the threat of outages with assistance to island reclamation districts for levee improvements, levee inspection and monitoring, and stockpiling of aqueduct pipes for minor repairs. The present measures do not eliminate the threat of severe rationing during an extended outage. Risk of outages can be reduced by water banking (additional terminal storage) or by upgrading existing facilities as described in the Alternatives section of this chapter.

EBMUD's goal has been to protect its customers from severe rationing. A 13 month long water supply outage in 2020 would cause rationing (deficiency) of up to 69 percent with the existing terminal storage. Additional storage of 100,000 acre-feet and 145,000 acre-feet will reduce rationing to 39 percent and 25 percent, respectively. A discussion of the current and future levels of rationing will be addressed in Chapter III. The following sections will discuss the risks of the water supply system failure and the impact of system failure on the customer.

Risk of System Failure

As shown in Figure II-2, the existing water supply is vulnerable to two major natural disasters: earthquakes and floods. The Pardee Reservoir dam, outlet tower, and tunnel are expected to survive earthquakes and floods without any interruption in service. Flooding is not expected to affect the local water system, which may, however, be affected by earthquakes. Nevertheless, the risk of a supply outage in the local system is small because damaged sections can be bypassed until repairs can be completed. The risk of damage to the Mokelumne Aqueducts in the Delta, the resulting water supply outages, and the impacts of Delta water quality on EBMUD customers will be discussed in the following sections.

RISKS IN THE DELTA

The Mokelumne Aqueducts in the Delta are vulnerable to potential damage from both earthquakes and floods. Outages occurring from scour caused by floods are estimated to last up to 4 months (EBMUD, Addendum, 1982). Outages lasting 4 months can be served by the 120-day standby supply available in existing terminal storage. However, earthquake damage in the Delta from relatively frequent high level ground shaking can cause a 13-month outage of the water supply. Very high level ground shaking can cause up to a 17-month outage. The various outage times associated with the levels of damage are shown in Figure II-12.

Threat of Flooding Near Aqueducts. Flood and tide stage-frequency relationships, based on measurements of 24-stage gages throughout the Delta, were developed by the COE. The COE data was used to calculate annual flood stage probabilities for the individual islands along the aqueduct route (COE, 1976). Probabilities of levee failure were based on the expected future subsidence of the Delta, the conditions of the levee, and the COE data (Converse, 1981).

Earthquake Faults Threatening the Delta. Although the 1906 earthquake damaged portions of the Delta, no earthquake-induced failure has occurred in the Delta during the 60 years that the Mokelumne Aqueducts have been in service. Seismic experts find the lack of high or very high ground shaking since 1906 unusual. The probability of relatively low level of ground motion may be best determined by the number of prior events, while high shaking levels may be determined by the physical characteristics of the earthquake faults. The period from 1906 to 1979 has been seismically quiet compared to a volatile period from 1830 to 1906 which contained several large seismic events, as shown in Figure II-13.

Types of Aqueduct Failure in the Delta

Figure II-12

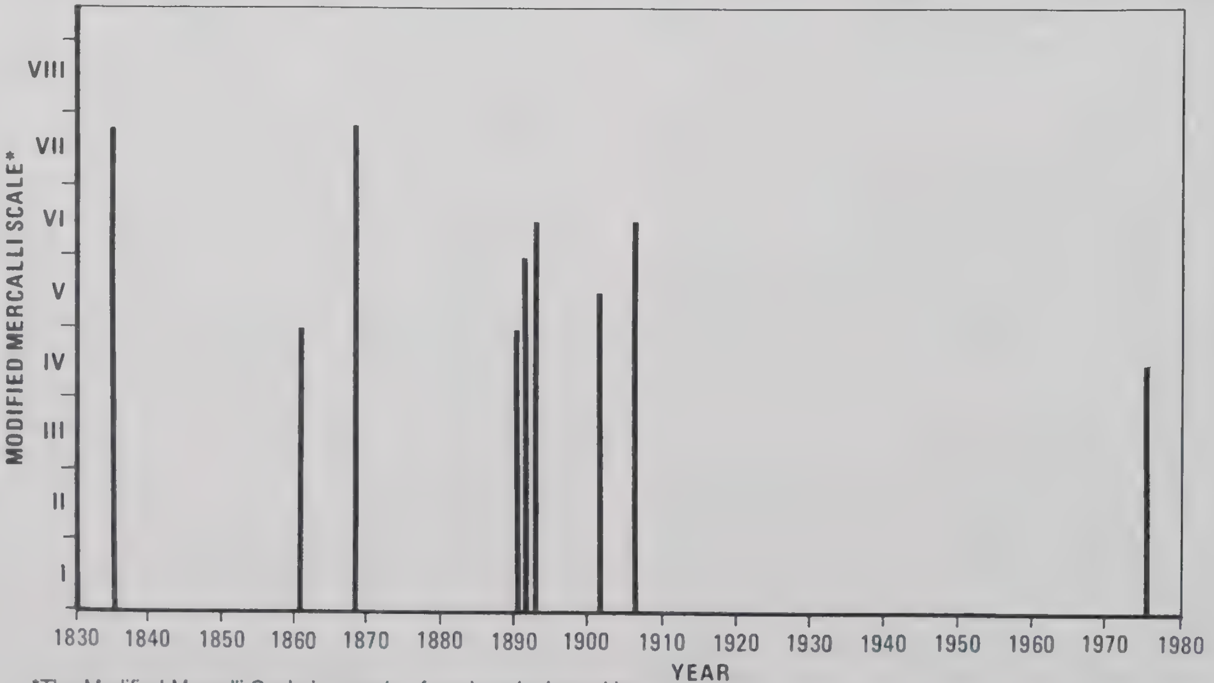
EVENT	ESTIMATED DAMAGE	OUTAGE**
EARTHQUAKE		
Very high level of ground shaking (greater than 0.25g)*	Extensive levee failure and all islands and tracts flooded. Elevated aqueducts completely collapsed. Extensive damage to all buried pipelines and river crossings.	Up to 17 months
High level of ground shaking (0.2 to 0.25g)*	Levee breaks at many locations and most islands flooded. Elevated No. 1 Aqueduct completely collapsed. Elevated No. 2 and No. 3 aqueducts collapsed at several locations. Breaks in buried pipelines at several locations. Extensive damage to pipelines at one or more river crossings.	Up to 13 months
Low to moderate ground shaking (0.1 to 0.2g)*	Levee breaks at several locations and one or more islands or tracts is flooded. Elevated No. 1 Aqueduct extensively damaged. Elevated No. 2 and No. 3 Aqueducts damaged at a few locations. Possible breaks in buried pipelines. Some damage to pipelines at one or more river crossings.	Up to 10 months
FLOOD		
Single break near elevated aqueducts	Levee break at one or more locations. Scour from flow through levee undermines pile supports. One or more aqueducts opposite the break are damaged. The island or tract is flooded.	Up to 4 months

*Based on technical studies by independent consultants of ground acceleration due to an earthquake.

**Outage means severance of Mokelumne River water supply.

History of Earthquake Intensities in the Delta Study Area

Figure II-13



*The Modified Mercalli Scale is a scale of earthquake intensities ranging from I to XII, with XII representing the greatest damage.

Source: Bolt, Jan. 1977

It should be noted that any estimates of future earthquakes affecting the Delta must contain considerable uncertainties because the historic data are limited. The period since 1906 is considered atypical of the long-term seismicity of the region. The recurrence interval of a major earthquake event is a statistical average over a long time period. An earthquake is not expected to occur every recurrence interval. However on the average, one earthquake should occur for each recurrence interval. Under these circumstances, it may be unwise to base arguments entirely on what has happened in terms of damage to the existing aqueducts.

As shown in Figure II-14, twelve active faults, which could create damaging ground shaking, have been identified within 50 miles of the Delta region. Three major fault systems (the Calaveras, Hayward, and San Andreas Faults) run north to south in the area west of the Delta and are capable of producing earthquakes with a maximum Richter magnitude up to 8.5. In comparison, the 1906 earthquake from the San Andreas Fault that devastated San Francisco had a Richter magnitude of 8.3. Nine additional north-south faults, located between 10 and 40 miles from the Delta, are capable of producing 6 to 6.5 Richter magnitude earthquakes.

The damage to the aqueducts from earthquakes is caused by the actual ground motion in the Delta. For example, the relatively small Antioch Fault (located closest to the Mokelumne Aqueducts) is capable of generating a 6.5 Richter magnitude earthquake, with high to very high levels of ground motion in the Delta. The remaining eleven faults, including the San Andreas, Hayward and Calaveras Faults, may generate even greater magnitude earthquakes than the Antioch. However, these eleven faults would cause a lower level of ground shaking (acceleration up to 0.2g) due to their greater distance from the Delta.

Historic earthquakes within 75 miles of the Delta area were used to calculate the recurrence relationship represented by the upper portion of the shaded area in Figure II-15. The physical characteristics of earthquake faults west of the Delta area were used to calculate the recurrence relationship represented by the lower portion of the shaded area. The solid line represents the judgement of expert seismologists as a compromise between the two methods.

POSSIBLE DAMAGE

Both the elevated and buried sections of the aqueducts in the Delta are vulnerable to damage from earthquakes and floods. Earthquake damage can be much more severe than flooding. Potential damage from earthquakes, unlike floods, can completely destroy the aqueducts in the Delta. The level of damage from an earthquake depends on the severity of the ground shaking. Potential damage from flooding is related to scour-induced failure and submergence-induced failure. The expected level of damage from earthquakes and floods is summarized in Figure II-12 and discussed more fully below.

Possible Damage due to Low Ground Shaking. Elevated sections of Aqueduct No. 1 are seismically weak due to the poor connection between the pipeline and its support. In the event of low level ground shaking (0.05g to 0.10g), Aqueduct No. 1 is considered likely to fail in many locations; however, Aqueducts Nos. 2 and 3 would remain unharmed and a Mokelumne water supply outage would not occur.

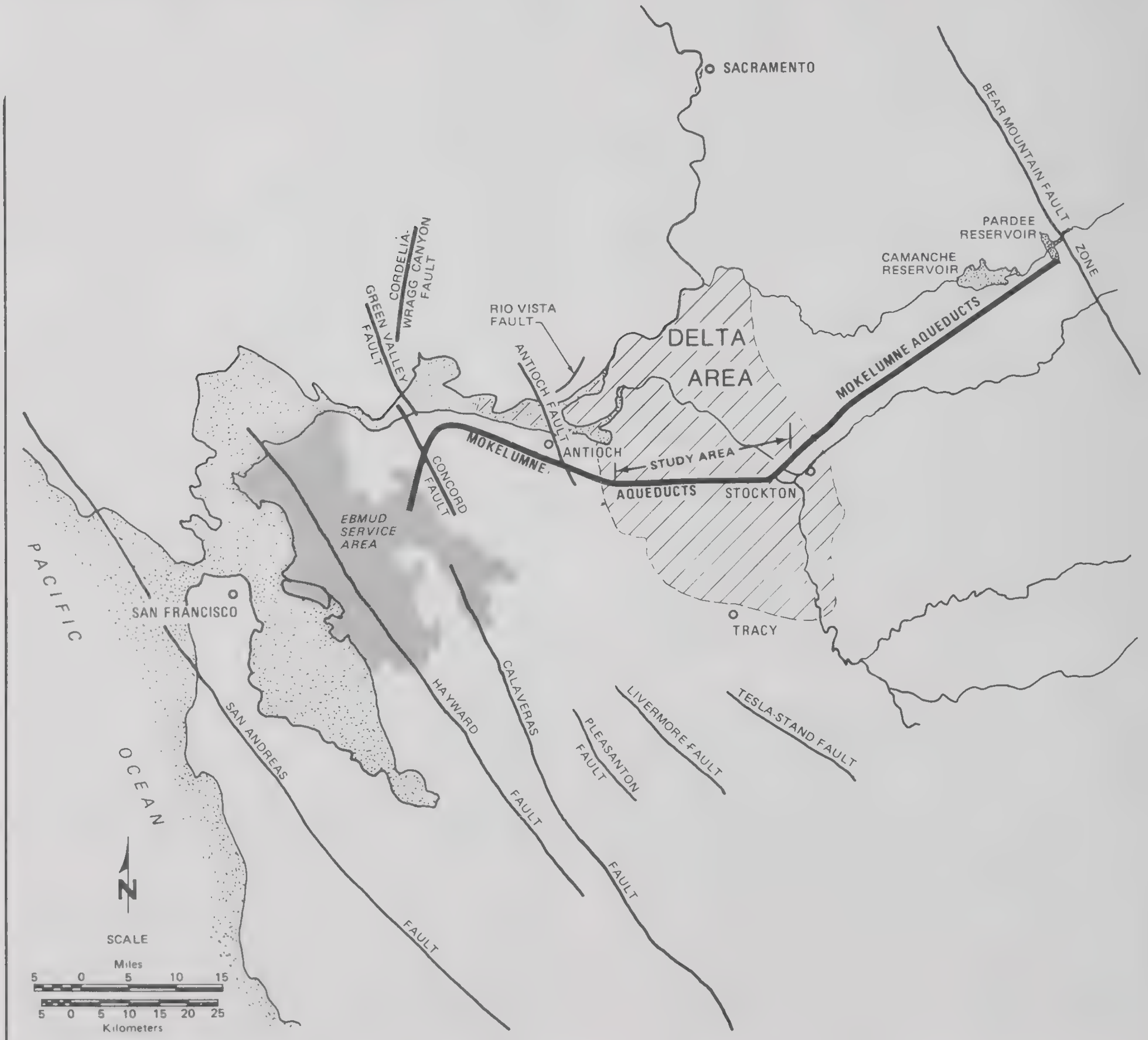
Possible Damage due to Moderate Ground Shaking. In the event of moderate level ground shaking (0.10g to 0.20g), the expected damage to the Mokelumne Aqueducts increases considerably. The elevated portion of Aqueduct No. 1 is expected to be extensively damaged, while the elevated portions of Aqueducts Nos. 2 and 3 may be broken at several locations. Levee breaks and island flooding are expected, with possible scour damage caused by the flooding. A few breaks in the buried sections of the aqueducts are expected, both on islands and at underwater river crossings. Moderate ground shaking is expected to have a recurrence interval of once every 23 years resulting in a complete outage of the Mokelumne supply. The estimate for the duration of such an outage is a maximum of 10 months to restore full supply.

Possible Damage due to High Ground Shaking. In the event of high level ground shaking (0.20g to 0.25g), the expected damage to the Mokelumne Aqueducts is extensive. This level of ground shaking can be caused by the Antioch Fault. The elevated portions of the Aqueduct No. 1 may be completely destroyed, while the elevated portions of Aqueducts Nos. 2 and 3 may be broken at many locations. Levee breaks and island flooding with possible scour damage is expected at several locations. Several breaks in the buried sections of the aqueducts are expected both on the islands and at one or more underwater river crossings. High ground shaking is expected to have a recurrence interval of once every 83 years resulting in a complete outage of the Mokelumne water supply. The estimate for the duration of such an outage is a maximum of 13 months to restore full supply.

Possible Damage due to Very High Ground Shaking. In the event of very high level ground shaking (over 0.25g), the expected damage to the Mokelumne Aqueducts is massive. This level of

.ive Faults Near the Delta

Figure II-14

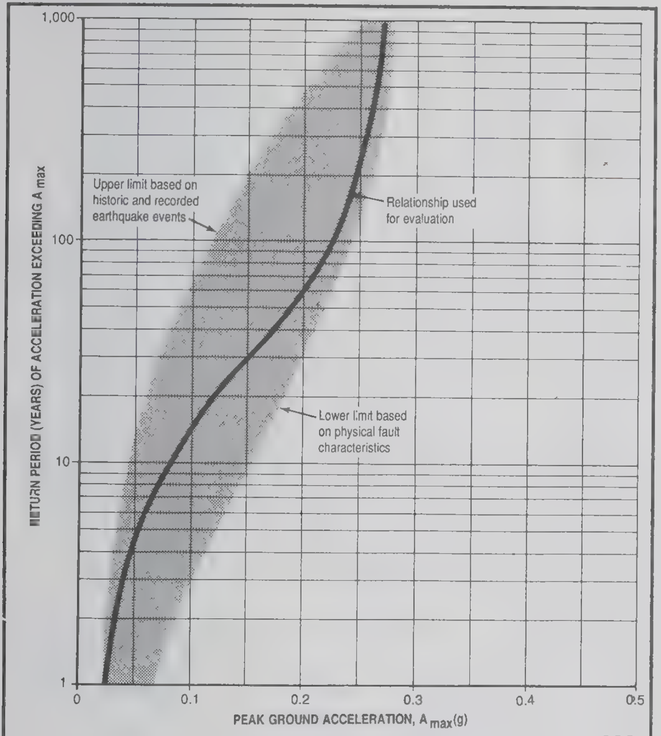


FAULT NAME	MINIMUM DISTANCE TO STUDY AREA (miles)	MAXIMUM CREDIBLE MAGNITUDE EARTHQUAKE (RICHTER SCALE)	PEAK GROUND ACCELERATION IN THE DELTA (g)
Antioch	11	6-1/2	0.27
Rio Vista	16	6	0.16
Tesla-Stand	17	6-1/2	0.19
Livermore Valley	22	6-1/4	0.13
Concord	22	6-1/4	0.13
Pleasanton	23	6	0.10
Calaveras	24	7	0.18
Green Valley	25	6-1/2	0.11
Hayward	34	7	0.13
Cordelia-Wragg Canyon	35	6-1/2	0.09
San Andreas (Northern)	52	8+	0.13
Bear Mountain	44	6-1/2	0.07

Source: Converse, 1981

Frequency of Maximum Earthquakes

Figure II-15



Source: EBMUD Addendum, 1982

ground shaking can also be caused by the Antioch Fault. The elevated portions of all aqueducts are expected to be destroyed. Many levee breaks and all islands are expected to be flooded, with additional scour damage at many locations. Many breaks in the buried sections of the aqueducts are expected on both the islands and all of the underwater river crossings. Very high ground shaking is expected to have a recurrence interval of once every 250 years resulting in a complete outage of the Mokelumne supply. The estimate for the duration of such an outage is 17 months to restore full supply.

Scour-Induced Failure. Levee failures in the Delta have shown that scour erosion can extend to depths exceeding 50 feet, which is deep enough to undermine the pile-supported pipeline sections. Any levee failure occurring near aqueduct channel crossings and along the north end of Woodward Island has a high probability of producing scour-induced aqueduct failure. The expected recurrence of a scour-induced aqueduct failure is once every 27 years (Converse, 1981) assuming present levee conditions. A scour-induced aqueduct failure is expected to result in a complete outage of the Mokelumne Aqueducts for up to 4 months.

Submergence-Induced Failures. Levee failure on any of the islands crossed by the aqueducts could result in submergence of the aqueducts. This submergence could result in aqueduct damage only if one is empty. When empty, the aqueducts have enough buoyancy to float free from their supports and fail. Aqueduct No. 1 is particularly vulnerable to submergence-induced damage, since it is not securely fastened to its supports. If the submerged aqueducts were never emptied, they might operate for some time without failure. However, the submergence would prevent easy access, repairs and normal maintenance of damaged aqueduct sections, and would require increased corrosion protection.

IMPACTS ON DELTA WATER QUALITY

At most times there is sufficient freshwater into the Delta to prevent saline water from entering the western end of the Delta. Inflow from natural runoff is occasionally increased by releases from upstream reservoirs, such as the federally-operated Lake Shasta (whose releases have a 4-day travel time to the Delta) or the state-operated Oroville Reservoir (whose releases have a 3-day travel time). The fresh water inflow rates, physical characteristics of the Delta channels, Pacific Ocean tidal stages and water exports affect the water quality in Delta. Delta water quality is degraded by salt water intrusion from the Pacific Ocean and Suisun Bay, agricultural drainage within the Delta, organic material in Delta soils, and poor water quality from some of the rivers. The water quality in the Delta improves when Sacramento River inflow is high or the exports are low.

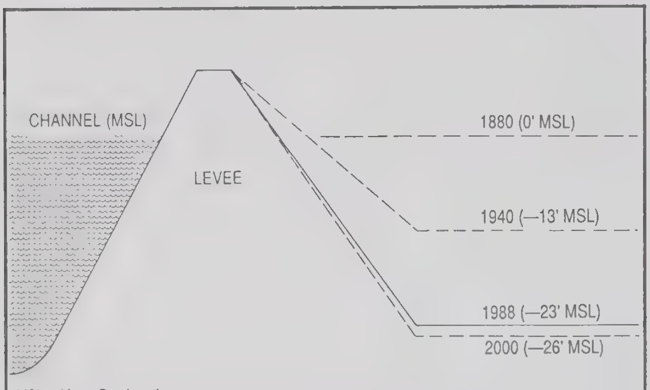
The islands and tracts in the Delta are protected from flooding by levees, which require rehabilitation due to subsidence and erosion. The occurrences of levee failures and subsequent flooding are increasing and subjecting the Mokelumne water supply to greater risk of an outage. The following sections will discuss the reasons for the overall subsidence of the Delta, the increased risk of levee failure, and the salinity intrusion affecting water quality.

Subsidence of Delta Levees. When most of the levees were built (between 1870 and 1875), the height of the levees above the island floor was 4 to 6 feet; today, to maintain the same elevation against flooding, the height of the levees ranges from 5 to over 25 feet above the island floor. This is because the island floors are continually settling while the levees are built up to prevent overtopping. Figure II-16 illustrates that some Delta islands are subsiding (up to 3 inches per year) due to the loss of peat deposits caused by oxidation, farming, erosion, and burning. The subsidence of the Delta islands has increased the risk of levee failures.

Reasons for Levee Failures. Many of the 60 islands and tracts in the Delta have been flooded at

Historical Subsidence of Island Floors

Figure II-16



Source: Assembly Office of Research, 1987

least once since their construction. Between 1932 and 1986, there were more than 50 levee failures, as shown in Figure II-17. Figure II-18 shows that between 1950 and 1986 alone there were more than 30 levee failures. Most of the flooded islands have been restored, in certain cases at a cost exceeding the appraised value of the island.

Salinity Intrusion due to Flooding. Salinity intrusion is the most serious water quality consequence of Delta flooding. Historically, levee failure and subsequent Delta island flooding have had adverse effects upon water quality and under certain conditions the effects were disastrous. For example, on June 21, 1972, a levee failure (500 feet wide and 75 feet deep) occurred, and Andrus Island and Brannan Island were flooded within three days causing considerable salinity intrusion.

During the emergency, certain Contra Costa Canal users received water with a chloride content as high as 440 milligrams per liter (mg/L). As a result, some industries had to cease operation. However, the chloride content of water delivered to most of the canal users was held to 120 mg/L only by mixing with flows from a temporary connection to the Mokelumne Aqueducts.

A model (COE, 1984) was developed to determine the effects of island flooding on water quality in the Delta. When island flooding occurs, water quality depends upon the total delta outflow, the tides, the size and location of the island(s), and the amount of water being exported. The model test of a single island flood concluded that levee failure and subsequent flooding of an island at low Delta outflow and high export increases salinity throughout most of the Delta. Another test of 19 islands flooded concluded that salinity increased rapidly until salinity at the intake of the Contra Costa Canal was 2,600 mg/L.

Effect of Levee Failure on EBMUD. EBMUD would experience similar salinity levels with Delta water at Indian Slough to those expected at Rock Slough. Figure II-19 correlates flooding and water quality modeled in the COE's study of the Delta. During low to moderate ground shaking, one to three islands crossed by the Mokelumne Aqueducts are expected to flood, resulting in a 10 month outage. The salinity level at Rock Slough peaked at 1,000 mg/L in the model study when one island flooded. The salinity in the model increased to 2,600 mg/L when 19 islands flooded; this could occur during high ground shaking resulting in flooding more than 3 islands used by the Mokelumne Aqueducts. EBMUD may not be able to use Delta water during an outage in the Delta; the water quality may not be acceptable, due to the possible salinity intrusion. Chapter IV discusses, in further detail, the impacts of levee failure on water quality in the Delta.

Impact of System Failure on the Customer

Damage of the Mokelumne water supply system due to earthquake and flood may severely impact the District's customers with water rationing and economic losses over an extended period of time.

HARDSHIP TO THE CUSTOMER

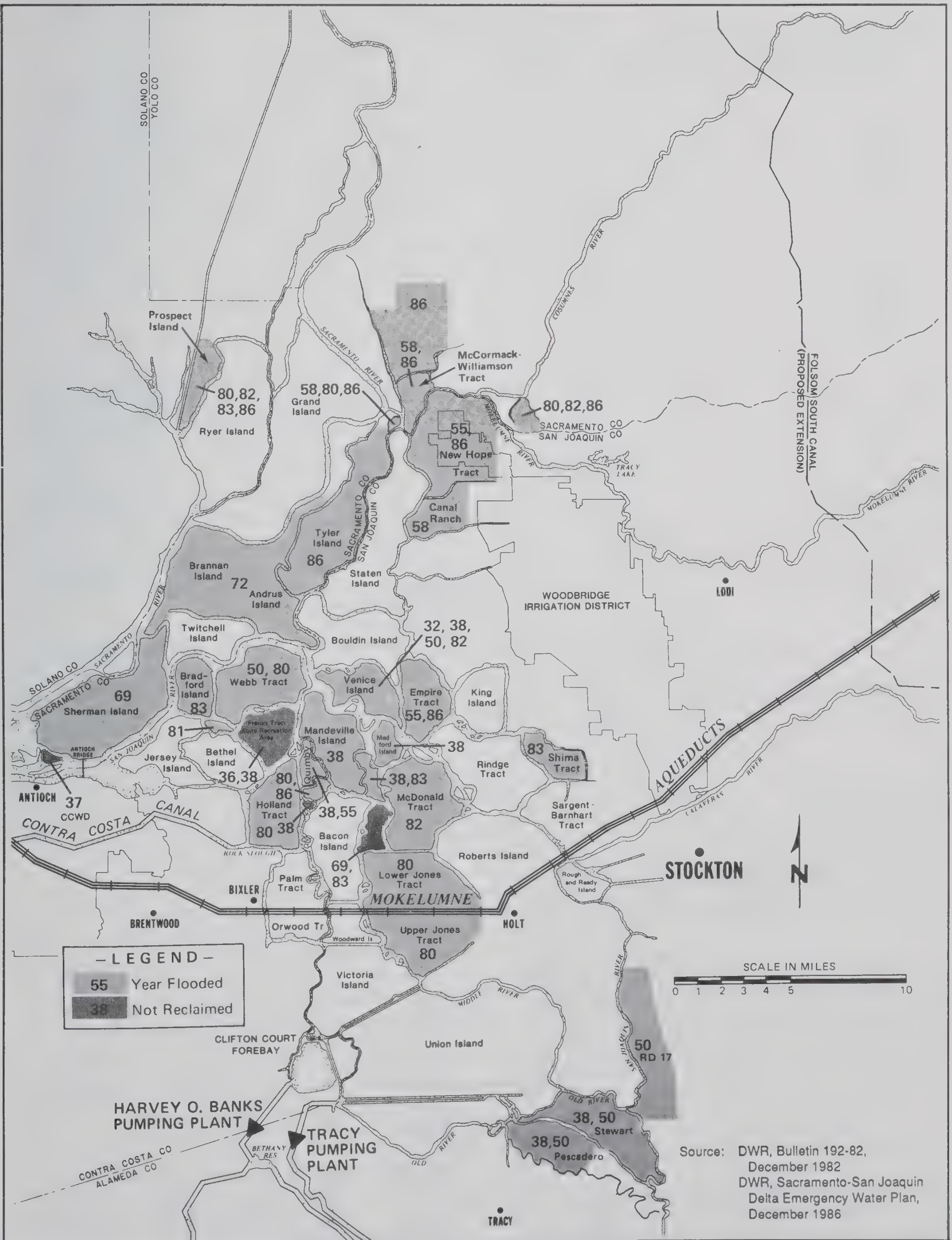
The Mokelumne Aqueducts in the Delta are susceptible to an outage of up to 17 months during a very high level ground shaking event, as discussed previously. Customers could experience water rationing as high as 78 percent during the 17-month outage. However, lower levels of ground movement are more likely and an outage time of 13 months is used for planning purposes. Even so, during a 13-month outage, customers may experience water rationing up to 69 percent by the year 2020.

Earthquakes in the Delta. Severe earthquakes are the most serious hazard to the aqueducts in the Delta. High to very high ground shaking may cause complete destruction of the aqueducts. The resulting outage of the Mokelumne water supply will include 69 percent rationing during a 13-month outage, unless additional water supplies are provided.

Indirect Impacts on Customers. EBMUD customers will incur economic losses due to water rationing caused by extended outages of the District's water supply. In a 1981 Residential Water Use Survey of the effects on customers of the rationing caused by the 1976-1977 drought, it was reported that 54 percent of residential customers interviewed lost a portion of their landscaping. The average cost to replace lost landscaping was $507 per account. Assuming that, during the drought, 54 percent of the

Delta Areas Flooded by Levee Failure or Overtopping 1932-86

Figure II-17



Delta Levee Failures, 1950 Through 1986

Figure II-18

ISLAND OR TRACT	DATE OF FAILURE
Venice	1950
Stewart	1950
Reclamation District 17	1950
Pescadero	1950
Webb	1950
Quimby	1955
Empire	1955
New Hope	1955
McCormack-Williamson	1958
Dead Horse	1958
Canal Ranch	1958
Sherman	1969
Mildred	1969
Andrus-Brannan	1972
Webb	1980
Holland	1980
Dead Horse	1980
Upper and Lower Jones	1980
Little Mandeville	1980
Prospect	1980
McDonald	1982
Venice	1982
Prospect	1982
Mildred	1983
Shima	1983
Bradford	1983
Prospect	1983
McCormack-Williamson	1986
New Hope	1986
Dead Horse	1986
Tyler	1986
Little Mandeville	1986
Prospect	1986
Source: DWR, 1986	

District's 263,000 household accounts lost $507, the total cost of replacing residential landscaping was $75 million in 1977 dollars ($115 million in 1988 dollars).

A number of intangible costs associated with rationing exist. These costs include a lack of water for normal housekeeping purposes such as laundering clothes, washing the car, rinsing the driveways and walkways, and increased water hardness/corrosiveness due to lower water quality. In the 1976-1977 drought, there were also economic losses to water-related businesses such as landscapers, car-washers, and laundries.

ALTERNATIVES

An earthquake could strike at any time causing extensive damage to the District's water supply system in the Delta. Outages lasting up to 17 months can be expected, although a 13-month outage is more likely. If the security of the water supply system is not improved ("do nothing"), the resulting rationing could be severe. Security improvement alternatives are: Foundation improvements in the Delta to reduce the risk of levee failure and aqueduct damage; a new secure aqueduct pipeline in the Delta to replace the existing aqueduct; water banking (additional terminal storage) to provide water supply during a water supply outage; interties with other agencies to access additional water supplies; Delta water use; additional water conservation and reclamation; and possible groundwater resources. The various alternatives to reduce the security risks are discussed in the following sections and shown in Figure II-20.

Do Nothing

Do nothing would mean a continuation of the present levels of water conservation and reclamation, possible use of Delta water without new facilities and the current level of levee maintenance. In the event of a disaster, EBMUD would not be prepared to minimize the adverse impact on EBMUD customers. Deterioration of the conditions in the Delta, particularly the levees, would over time mean increased vulnerability to damage and collapse of the pipelines with a worsening of the potential impact on EBMUD customers.

The possibility of adverse health risks must be acknowledged when considering the use of Delta water. In 1972, the flooding of Andrus and Brannan Islands increased salinity levels in the Delta. Contra Costa Water District (CCWD), a large user of Delta water, purchased EBMUD water because of unacceptable levels of chlorides in the Delta water. Also, CCWD is currently investigating storage of higher quality water in their proposed Los Vaqueros Reservoir, for use when the Delta water quality is extremely low.

The earthquakes producing damage to the aqueducts in the Delta may also increase the salinity of Delta waters. The ground motion created by the earthquake may produce multiple levee failures which will cause island flooding. As previously discussed, the COE model of levee failures and water quality shows that the flooding of 19 Delta islands could result in a salinity of 2,600 mg/L at Rock Slough. Salinities greater than 500 mg/L are not recommended for public consumption over an extended period (California Health and Safety Code, Title 22).

The "do nothing" alternative will continue with the current level of levee maintenance. Thus, the continuing deterioration of the Delta levee system will increase the aqueduct's vulnerability to flooding. As

Flooding Correlation with Salinity

Figure II-19

CONDITIONS	ISLANDS FLOODED[1]	RECURRENCE INTERVAL, YEARS[2]	AQUEDUCT OUTAGE, MONTHS	PEAK SALINITY AT ROCK SLOUGH[3]
EARTHQUAKES				
Low / Moderate Ground Shaking	Up to 3	1 in 23	Up to 10	1,000[4]
High Ground Shaking	Greater than 3	1 in 83	Up to 13	2,600[5]
FLOODING				
Flooding to +8 MSL with Scour Damage	Up to 3	1 in 32	Up to 4	1,000[4]
Flooding to >+8 MSL with Scour Damage	Greater than 3	1 in 192	Up to 4	2,600[5]

NOTES:
[1]Islands used by Mokelumne Aqueducts.
[2]Addendum, 1982
[3]Corps of Engineers Model Study, 1982.
[4]Corps of Engineers study modeled on McDonald Island flood.
[5]Corps of Engineers study modeled on 19 islands flooded including Orwood, Woodward and Jones.

Alternatives for Improving Security

Figure II-20

ALTERNATIVE	REMARKS
1. DO NOTHING	Continue risk of extended water system outage due to flooding or earthquake damage to aqueduct pipelines in the Delta, with need for severe water rationing during the outage.
2. WATER CONSERVATION (Additional Measures)	Continue existing program and implement additional feasible measures which would save a total of 7 MGD by 2020 ($0.6 million per year); this would not provide security against an extended outage.
3. WATER RECLAMATION (Additional Projects)	Continue existing program and implement additional feasible projects which would save about 5 MGD by 2020 ($15 million); this would not provide security against an extended outage.
4. LEVEE AND FOUNDATION IMPROVEMENTS IN THE DELTA	Continue levee maintenance; upgrade levees; investigate possible levee reinforcement and improvement of pipe supports; and do testing and preliminary engineering for potential future pipeline replacement ($10 million); this would reduce some risks of outage but would not solve the security problem.
5. NEW AQUEDUCT PIPELINE ACROSS THE DELTA	Pipeline designed to withstand maximum earthquake would provide security against an extended outage ($265 million); field testing of pipeline support designs and studies of levee reinforcement are needed; future implementation of the USBR contract could affect the size of the pipeline.
6. WATER BANKING (Additional Terminal Storage)	Additional storage of 145,000 acre-feet would provide security against a 13-month outage with rationing limited to a 25% reduction of demand during the outage, at a projected demand of 270 MGD in the year 2020 ($152 to $186 million).
7. INTERTIES WITH OTHER AGENCIES	No water agency has significant long-term surplus water that EBMUD could depend on for security against an extended outage; increase in capacity of existing connections with San Francisco's Hetch Hetchy system through Hayward should be studied.
8. DELTA WATER USE	Flooding due to levee failure or earthquake would cause salt water intrusion into the Delta with extremely high levels of salinity making the water unusable, with no Mokelumne water for blending.
9. GROUNDWATER RESOURCES	Usable groundwater resources within EBMUD are 1 to 2 MGD, which is inadequate for security.

mentioned earlier, in the event of an extended outage, severe rationing of the water supply will be required.

EBMUD customers will experience severe hardships in the "do nothing" alternative as described previously.

Water Conservation

EBMUD's water conservation efforts began in the early 1970's and have continued with an increased emphasis in recent years. Rationing in 1977 provided first hand experience with customer reaction to a short-term water shortage emergency and the impacts of water use restrictions. It is reasonable to assume that an acceptable level of short-term water conservation through rationing would be required in the event of a disaster, and should be part of EBMUD's water supply planning.

The alternative of expanding EBMUD's water conservation program to keep water demand during normal conditions at a low enough level to survive an extended outage of the Mokelumne supply would have to be based on extreme measures. Demand is currently about 220 MGD and is projected to increase to 280 MGD in 2020. The existing standby storage in the terminal reservoirs will accommodate a demand of only 81 MGD for 13 months, which requires reductions of 63 percent today and 71 percent in 2020.

Chapter III will show that continued implementation of the existing water conservation program could achieve a reduction of 4 MGD in 2020. Additional measures considered to be the most reasonable, feasible, and publicly acceptable would achieve an additional 3 MGD savings, for a total reduction of 7 MGD. Theoretical measures would have a potential for saving an additional 17 MGD in 2020 by getting into the realm of mandatory measures; however, these measures are unproven and could be costly to customers. For example, mandatory replacement of toilets with ultra-low flush models by all residential customers could save about 13 MGD by 2020, but would cost several hundred dollars per household.

A permanent reduction of current demand to 81 MGD (63 percent reduction) would require extraordinary changes in water use by residential, industrial, commercial, institutional, and irrigation customers with significant investment by customers in water saving equipment. There would be major impacts on the economy and lifestyle of the East Bay area. The experience with rationing during 1977 demonstrated what EBMUD customers had to do to achieve only a 39 percent reduction in demand. Landscape irrigation was drastically reduced or eliminated, people flushed toilets and used showers less frequently, and non-essential water uses were suspended. Industrial and institutional customers became more efficient in their water use by installing new equipment, repairing leaks, and modifying processes, much of which continues today making further reductions in water use more difficult.

If the permanent reduction under normal conditions was less, for example a 35 percent reduction to a level of 143 MGD, the restrictions on water use would be similar to the rationing in 1977 but with long-term adverse impacts on the economy and lifestyle. Then in the event of an extended outage, extreme measures would be necessary to further reduce demand by 63 percent.

It is difficult to determine the reductions that would be assigned to the various categories of customers. However, if the impact on the economy of the region were to be minimized then most of the burden for the 63 percent reduction would have to be borne by an even greater reduction in residential and irrigation water uses (together they account for about two-thirds of current demand).

As new development receives water service and demand increases, the extreme water conservation measures would have to become stricter to be able to survive a 13-month outage. The 63 percent would increase to a 71 percent reduction in 2020 to achieve a demand level of 81 MGD.

EBMUD's effort in 1987 to have customers voluntarily reduce demand by 12 percent during the last half of the year did not achieve that result, although it may have been responsible for the demand not increasing. Obviously, the intended results of a water conservation program are not reliable and cannot be predicted. Public acceptance is an important factor.

Water pricing has been investigated as a water conservation measure, but EBMUD experience and studies show that under normal water supply conditions it is not effective. For example, the 50 percent increase in water rates for water service to customers at higher elevations over the past five years has shown no reduction in water use. Furthermore, EBMUD is required by law to charge no more than the actual cost of providing water service. On the other hand, the 1977 experience with rationing showed that the threat of severe financial penalties for excessive use coupled with the declaration of an emergency can be effective on a short-term basis.

Water use efficiency through conservation is an important element of water supply management; however, it is not a viable alternative for security of the EBMUD water supply against extended outages because the demand reduction needed (63 to 71 percent) would require extraordinary changes in water use by EBMUD customers that would be expensive and would adversely impact the economy and lifestyle of the East Bay area.

Water Reclamation

The reuse of water through water reclamation is an option for non-potable water uses such as irrigation and industrial cooling. Feasible reclamation projects require a large non-potable demand near a wastewater source with limited treatment requirements. Chapter III will show that current reclamation projects save approximately 4.7 MGD, and additional projects could reduce demand by an additional 5 MGD. Future reclamation projects could provide some additional savings, but not in the range of the 139 to 189 MGD reduction necessary to be able to survive a 13-month outage of the Mokelumne supply (see water conservation discussion above). Current, water reclamation and conservation would reduce the projected demand in 2020 from 280 MGD to about 270 MGD. Water reclamation cannot alone or in combination with water conservation be a viable alternative for security of the EBMUD water supply against extended outages.

Levee and Foundation Improvements in the Delta

EBMUD participates in the maintenance, repair, and upgrading of levees to avoid deterioration of the conditions that could cause levee failure due to sloughing, erosion, or over-topping. From 1981 through 1987, EBMUD contributed $1.3 million to this reclamation work, and its additional contribution for completing it would be about $2.0 million. This would maintain the existing level of risk of failure. However, it would not provide protection against levee failure caused by an earthquake and the potential for an extended outage of the water supply system. Earthquakes cause levee failures because of the poor foundation conditions (the peat and sandy soils on which the levees were built) and the poor quality of levee construction.

If the levees could be adequately reinforced, the foundation conditions under the levees and aqueduct pipelines adequately improved, and the pipeline supports and piles reconstructed to resist very high levels of groundshaking due to a major earthquake, then the risk of an extended outage of the water supply system would be substantially reduced. However, this is not feasible because such levee reinforcement and foundation improvement technology is only conceptual and unpredictable, and the cost of reconstructing the pipeline supports and piles would exceed that of building a separate new pipeline across the Delta.

LEVEE REPAIRS AND MAINTENANCE

Repairs and maintenance of Delta levees since 1981, including minor repairs, upgrading, and raising levees at river crossings, have cost $3.2 million of which EBMUD has contributed over $1 million. An inspection conducted in March 1987 by the District's Aqueduct Section indicated that further levee improvements will be necessary on Woodward Island, Palm Tract, and Lower Jones Tract. The District is planning an additional $2 million (1988 dollars) for completing this work and may spend another $6 million for further levee improvements. The proposed improvements would be eligible for state reimbursement under the Way-Mobley Act described earlier in this chapter and could extend over 3 years.

Substantial levee improvements have been made on Woodward Island. Several locations along the east and south levees will need to have the crest elevations raised. Palm and Orwood Tracts are separated by a railroad embankment similar to Lower and Upper Jones Tracts. Although the Mokelumne Aqueducts do not cross Palm Tract, flooding of Palm Tract would endanger the aqueducts on adjoining Orwood Tract. Required levee improvements on Palm Tract include raising the elevation and widening the levees.

The aqueducts also do not cross Lower Jones Tract; however, flooding of Lower Jones Tract will pass through the trestle section of the embankment that separates Lower and Upper Jones Tracts. Since the flooding of Lower and Upper Jones Tracts in 1980, the District approved a resolution to contribute $50,000 toward levee improvements on Lower Jones Tract. Due to the opening in the railroad embankment, Lower Jones Tract levees are even more vital to the security of the Mokelumne Aqueducts. Recommended levee improvements on Lower Jones Tract consists of raising the elevation and widening the levees.

Levee repairs and maintenance provide protection for the existing aqueducts against levee failure due to sloughing, erosion, or over-topping. However, this work will not provide protection against damage to the existing aqueducts due to low/moderate levels of ground shaking and will not reduce the risk of an extended outage of the Mokelumne water supply. There is preliminary engineering work that can be done for future improvements in the Delta that would

reduce some risks of water supply outage by being prepared for a disaster:

- Field testing and preliminary design of possible pile support systems and future aqueduct pipeline across the Delta to shorten the response time in the event of a disaster; and
- Investigation and feasibility studies of levee reinforcement and of modification of supports under the existing aqueduct pipelines for reducing the risk of aqueduct damage due to flooding and lower levels of groundshaking caused by earthquakes.

FIELD TESTING AND PRELIMINARY DESIGN

Field testing of possible pile supports would be required for a future aqueduct replacement. Three areas south of EBMUD's existing right-of-way on Woodward Island and Orwood Tract have been proposed as possible sites for conducting a pile testing program. The piling testing program would be located along a possible future aqueduct alignment up to 500 feet south of the existing pipeline. It has been estimated that pile testing program would take two years to accomplish at an estimated cost of approximately $1.5 million in 1988 dollars.

In the event of damage to the Mokelumne Aqueducts, it would be necessary to begin repairs or replacements as soon as possible; therefore, it is necessary to begin the design of a secure aqueduct based on the results of the pile testing. The cost of preliminary design of a new pipeline depends on effort required, which cannot be determined until after the investigation, testing and studies.

Investigation and Feasibility Studies. Preliminary studies will identify the methods necessary to improve the security of the water supply in the Delta. These studies will include investigations to modify the support of existing aqueducts and to reinforce the levee crossings.

Modification work may include placement of reinforced concrete, steel support structures, and grouting. The new steel support structures will be anchored to the concrete bents. The cost to modify the existing aqueduct supports may be up to $25 million in 1988 dollars. However, these studies will be required before design work can begin.

Modifications to Aqueduct No. 1 supports would minimize the damage in frequent low level ground shaking expected to occur once in 23 years. These modifications would not be effective against outages due to moderate or high levels of ground shaking. Severe rationing of up to 69 percent would still be required during 13-month outage. Aqueduct modifications would not increase the District's ability to meet demands during a drought.

Levee reinforcement would minimize the risk of levee failure at the river crossings and the potential for damage to the aqueducts from scour. The levees would be reinforced for 500 feet on either side of the aqueducts on each levee at the aqueduct river crossings. Locations of levee reinforcement include crossings at San Joaquin River, Trapper Slough, Middle River, Old River, and Indian Slough. Figure II-21 shows the possible location of the levee reinforcement.

Preliminary studies and testing would be required before levee reinforcement design work could begin. Reinforcement of the Delta levees has not been attempted and its effectiveness is not known. Preliminary studies in the Delta will determine the feasibility and appropriate design for reinforcing the levees. The studies must be completed before levee testing can begin. The estimated cost for both the levee and aqueduct modification studies is approximately $0.5 million, in 1988 dollars.

New Pipeline Across the Delta

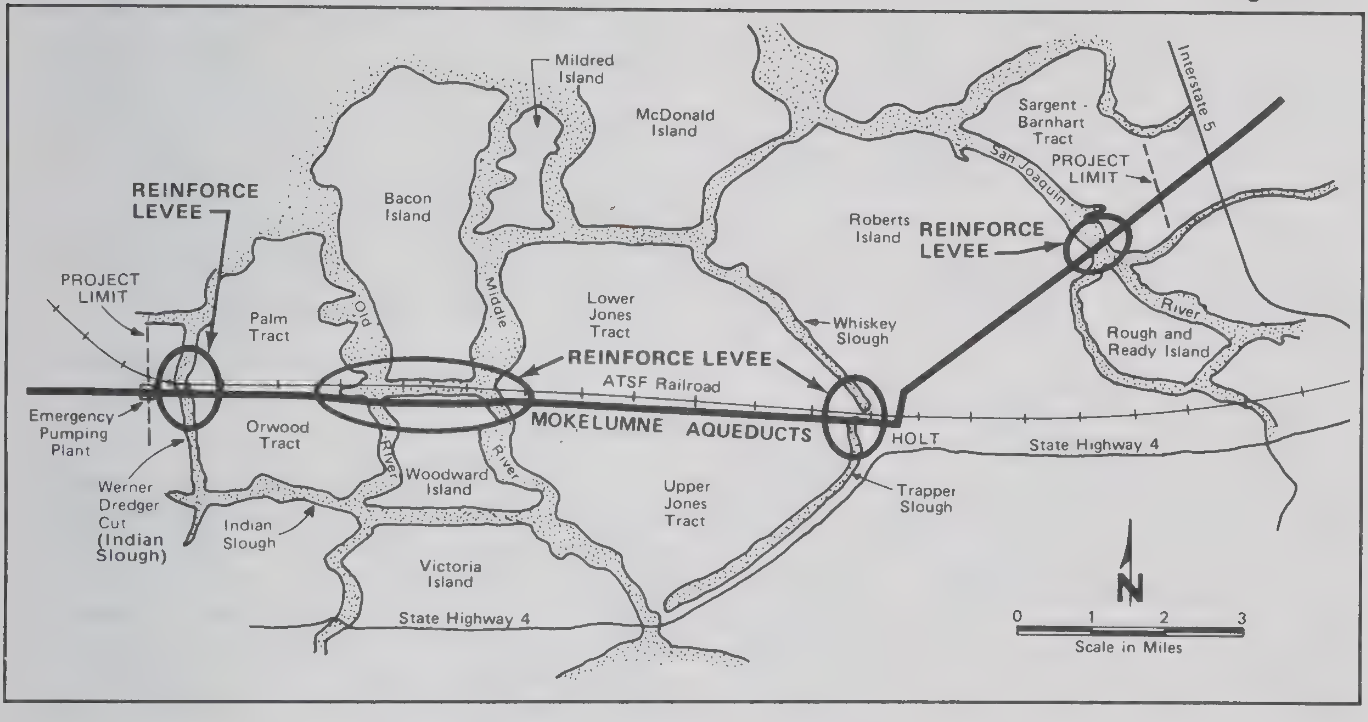
Construction of a new pipeline or pipelines across or around the Delta could provide secure delivery of the Mokelumne supply. It would be designed to survive the estimated maximum groundshaking due to earthquake and long-term inundation if an island is flooded. Full capacity would require two 86-inch pipelines. Preliminary studies indicate that the most cost-effective alignment is parallel to the existing aqueducts. Aqueduct alternatives include: An elevated aqueduct; a buried aqueduct; an aqueduct built on a causeway; and an aqueduct around the Delta.

The implementation of EBMUD's contract with the U. S. Bureau of Reclamation for delivery of supplemental water from the Folsom South Canal could affect the size of the pipeline. Because of the high cost of this alternative, the possibility of a delivery capacity above 325 MGD should be considered. This might require delaying design and construction until the legal obstacles related to the USBR contract are cleared.

The pile supports under the elevated pipe would be designed to withstand the maximum expected earthquake forces and to accommodate the liquefiable sandy foundation soils. The design would also take into account the effects of scour around pipe supports from the flow through a levee break. Field testing of possible pipe support and pile system designs and investigation of levee reinforcement at river crossings

Areas for Levee Reinforcements

Figure II-21



would be required. The estimated total project cost for the double pipeline is $265 million.

The buried aqueduct would be designed to survive the maximum ground shaking due to earthquakes and would not be affected by the inundation of any of the islands. The estimated construction cost of a double pipeline is $305 million (1988 dollars).

An aqueduct system built on an earthen causeway would be designed to survive the maximum ground shaking due to earthquakes and would be elevated above flood levels. The estimated construction cost of a double pipeline is $535 million (in 1988 dollars) also will require preliminary engineering in the Delta.

Another secure aqueduct alternative would be built around the vulnerable Delta area. The route would extend around the southern end of the Delta, from Bixler to Holt. The estimated construction cost of a double pipeline is $415 million (in 1988 dollars).

Water Banking (Additional Terminal Storage)

EBMUD has five terminal reservoirs in the East Bay hills which provide a total of about 138,000 acre-feet of usable storage. Terminal reservoirs provide the following five functions:

- Emergency Standby - storage maintained to meet demand during short term disruptions of supply when there is insufficient time to impose mandatory rationing. It provides a minimum of 120 days of supply at normal demand. This is the time needed to repair damages to tunnels, pumping plants, and pipelines. This emergency standby is also maintained during a two year drought period.

- Seasonal Regulation - store Mokelumne River in the winter and spring, when Sierra runoff occurs and demand is low, for use during the high demand period in the summer months.

- Drought Reserve - for dry periods such as 1976-1977 and other years on hydrologic record.

- Develop Local Yield - collect and store storm runoff from the reservoir watersheds. The storage capacity for regulation and local yield is shown in Figure II-22.

- Environmental Preservation and Recreation - 27,000 acres of watershed land on which these reservoirs are located provide open space and water related recreation. These lands and water constitute a priceless urban refuge permanently protected from development. These watershed lands and the adjacent regional parks include an 80-mile system of trails wandering east of the Oakland-Berkeley Hills.

The total amount of unusable storage, as shown in Figure II-22, in the reservoirs is 17,500 acre-feet. This is storage space that is generally unusable and is dependent on the elevation of the outlet works. The total amount of storage space provided for regulation, also shown in Figure II-22, varies from a minimum of 13,500 acre-feet in April to a maximum of 37,000 acre-feet in November.

At the projected demand of 270 MGD in the year 2020, the additional storage and costs to limit rationing would be:

Limit on Rationing	13-month Outage	Estimated Range of Costs
39 percent (reduction)	100,000 AF	$122M-$150M
25 percent (reduction)	145,000 AF	$152M-$186M

Additional terminal storage will increase the standby storage and reduce severe rationing during an extended outage. The 39 percent limit is existing policy; the 25 percent limit would be a change in policy to reduce the severity of rationing as will be discussed in Chapter III.

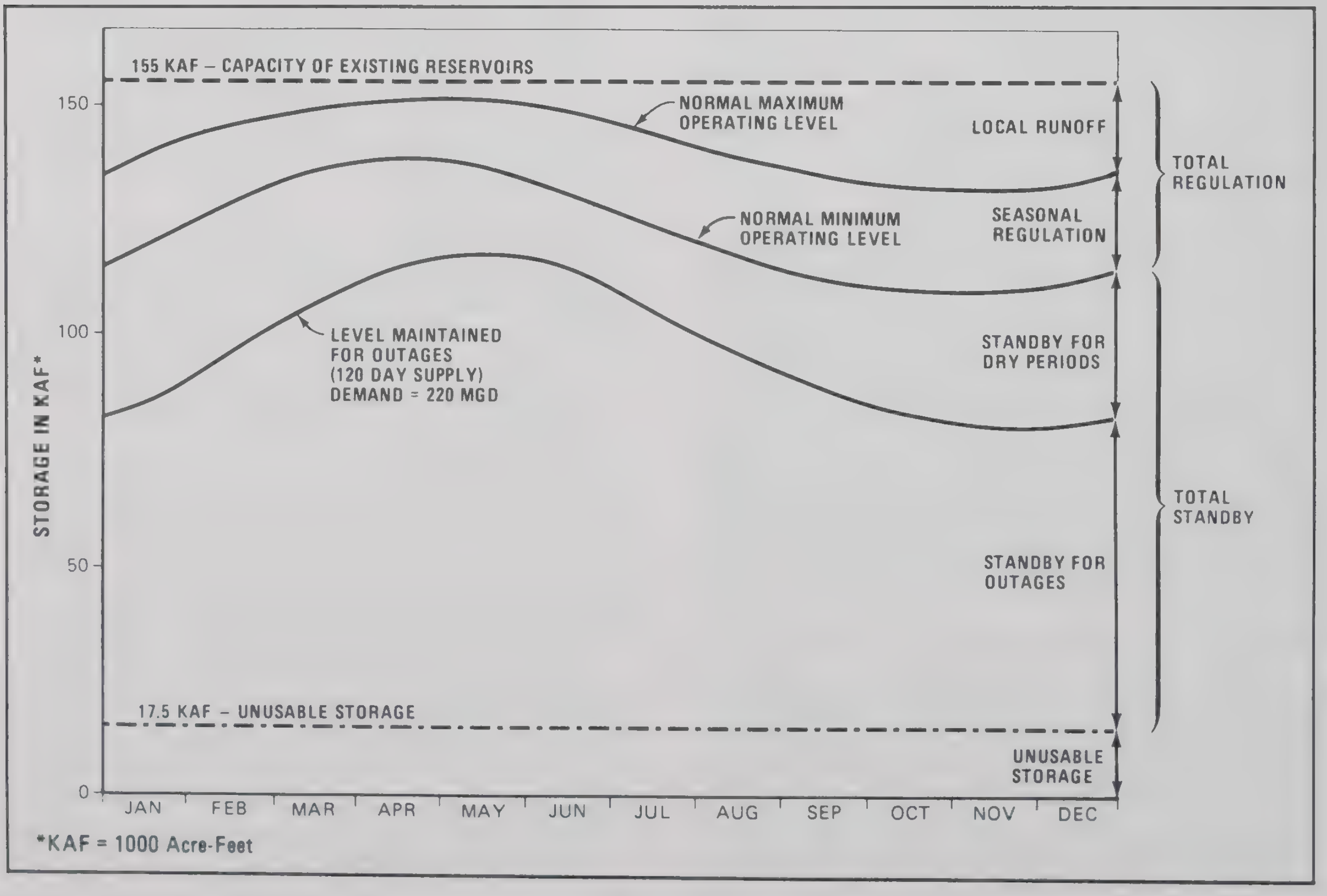
Given the various combination of events, possible damage, and possible outage times, a 13-month outage is a more likely event for planning purposes than a 17-month outage. The maximum 17-month outage would require larger additional storage, but poses a much lower risk. Figure II-23 illustrates the amount of storage needed to provide water during an outage at various levels of rationing. By the year 2020, EBMUD's existing terminal storage would result in customer rationing of 69 percent in a 13-month outage without additional terminal storage.

The operational cost of filling a new reservoir would range from $11 to $17 million (1988 costs), depending on the site and the size.

In the event of damage to the Mokelumne Aqueducts, it would be necessary to begin repairs or replacement as soon as possible. This alternative would provide sufficient storage to allow time for the repairs or replacement. In combination with this alternative, it will be necessary to continue the levee repair and maintenance program and begin the study of levee reinforcement and pile testing in preparation for the design of a secure aqueduct.

Functions of Terminal Reservoirs

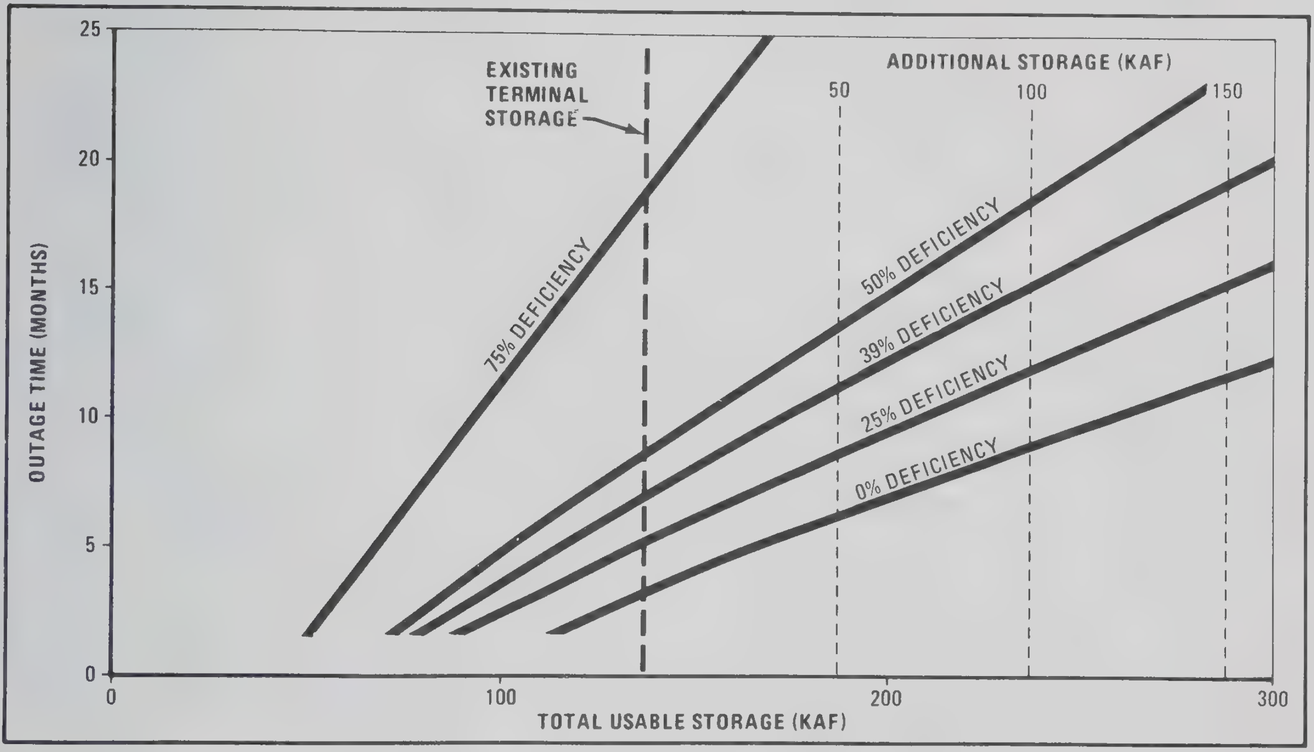
Figure II-22



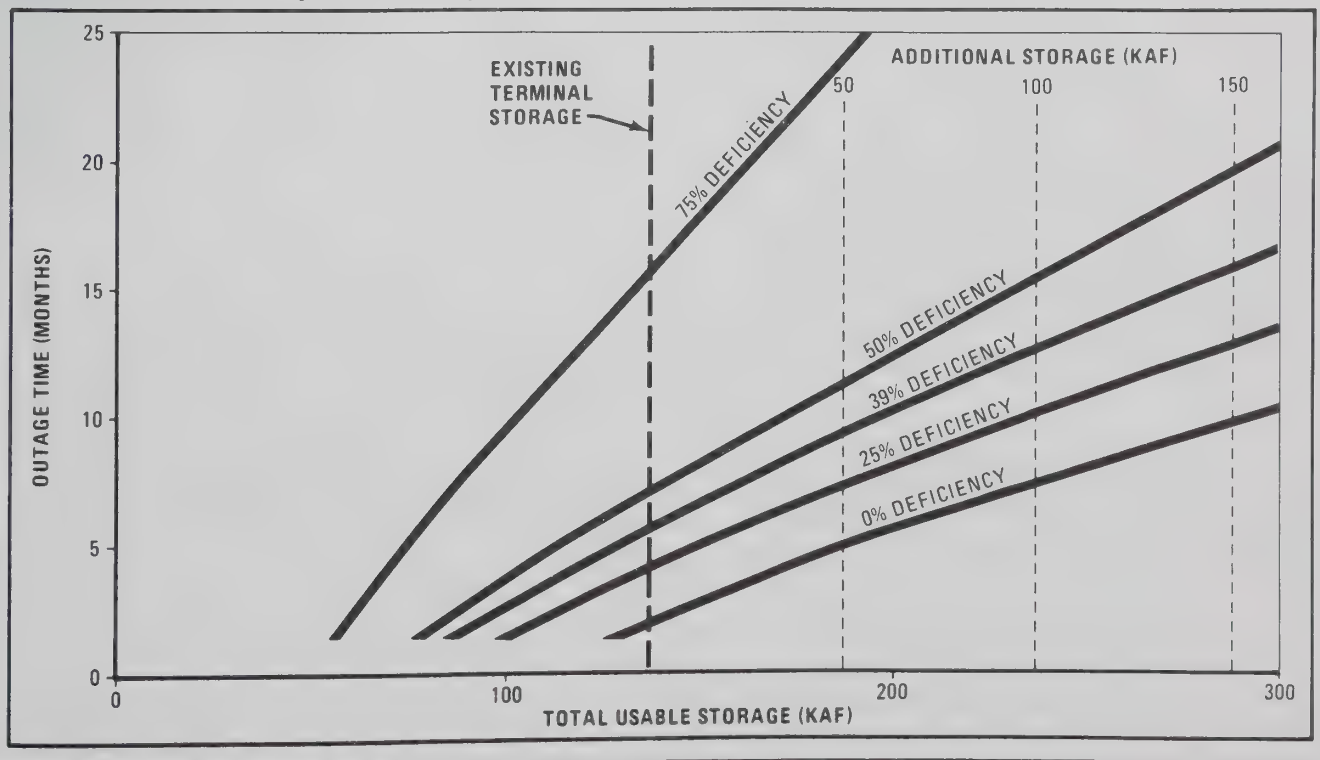
Storage Requirements at Different Levels of Deficiencies

Figure II-23

1990 Demands (225 MGD)



2020 Demands (270 MGD)



Interties with Other Agencies

Adjacent and nearby water supply systems of other agencies offer the possibility of emergency supplies during an extended outage of the Mokelumne system. No utility has a significant long-term surplus that EBMUD can depend on for the required water quantity and outage time. In addition, water rights and environmental issues associated with any change in source or place of use could be significant. Nevertheless, intertie possibilities need to be considered.

San Francisco's Hetch Hetchy system could be connected to EBMUD through the City of Hayward, with which EBMUD has emergency connections, or by constructing a major transmission pipeline from Walnut Creek south to Sunol in the Livermore Valley (27 miles) or from the Brentwood area south to a point in the Central Valley (25 miles) as shown in Figure II-24. The water quality would be similar to that of the Mokelumne River. The existing Hayward connections can deliver only 5 to 10 MGD, whereas a major transmission pipeline could deliver a significant quantity of water. Such a pipeline could cost approximately $100 million. Any interties with the Hetch Hetchy system might help in the event of a Mokelumne supply outage, if the water were available; but this is an uncertainty.

The Contra Costa Water District (CCWD) obtains its water supplies from Rock Slough in the Delta, under a contract with U.S. Bureau of Reclamation, and Mallard Slough, under its own water rights. The system has no appreciable storage, but CCWD is planning the construction of Los Vaqueros Reservoir. A supply from the Delta through CCWD is not a viable source that EBMUD could depend on because the flooding of islands resulting from a disaster in the Delta could cause salt water intrusion from the Bay with extremely high salinity levels. If use of Delta water were feasible, then EBMUD could take delivery of its American River entitlement directly from the Delta as it did in 1977, rather than going through CCWD.

The South Bay Aqueduct of the State Water Project extends through the southerly part of the Livermore Valley. Its capacity appears to be fully contracted for. The source is the Delta, (Clifton Court) which is further southeast than Rock Slough. The impact of salt water intrusion might be less at Clifton Court depending on the type of disaster and the extent of flooding. Apart from the salinity problem, EBMUD's major treatment plants are not equipped to treat Delta water. The intertie would require the construction of a treatment plant which would cost over $370 million (1988 dollars). In addition, an 111-inch diameter pipeline estimated to cost about $40 million would be needed. The general pipeline alignment could extend from Bethany Reservoir (South Bay Aqueduct) to the Mokelumne Aqueducts near Brentwood.

Delta Water

During an extended outage resulting from flooding in the Delta, the water quality could deteriorate due to salt water intrusion and inflows of agricultural drainage. The District's major water treatment plants are not equipped to treat Delta water; equipping them to treat Delta water during emergencies would be expensive. A new treatment plant, which would be used only in an emergency, is estimated to cost $370 million, in 1988 cost. Furthermore, the rapid start-up of an unused treatment plant would result in inconsistent water quality. A detailed discussion of the advantages of using Delta water is included in Chapter IV.

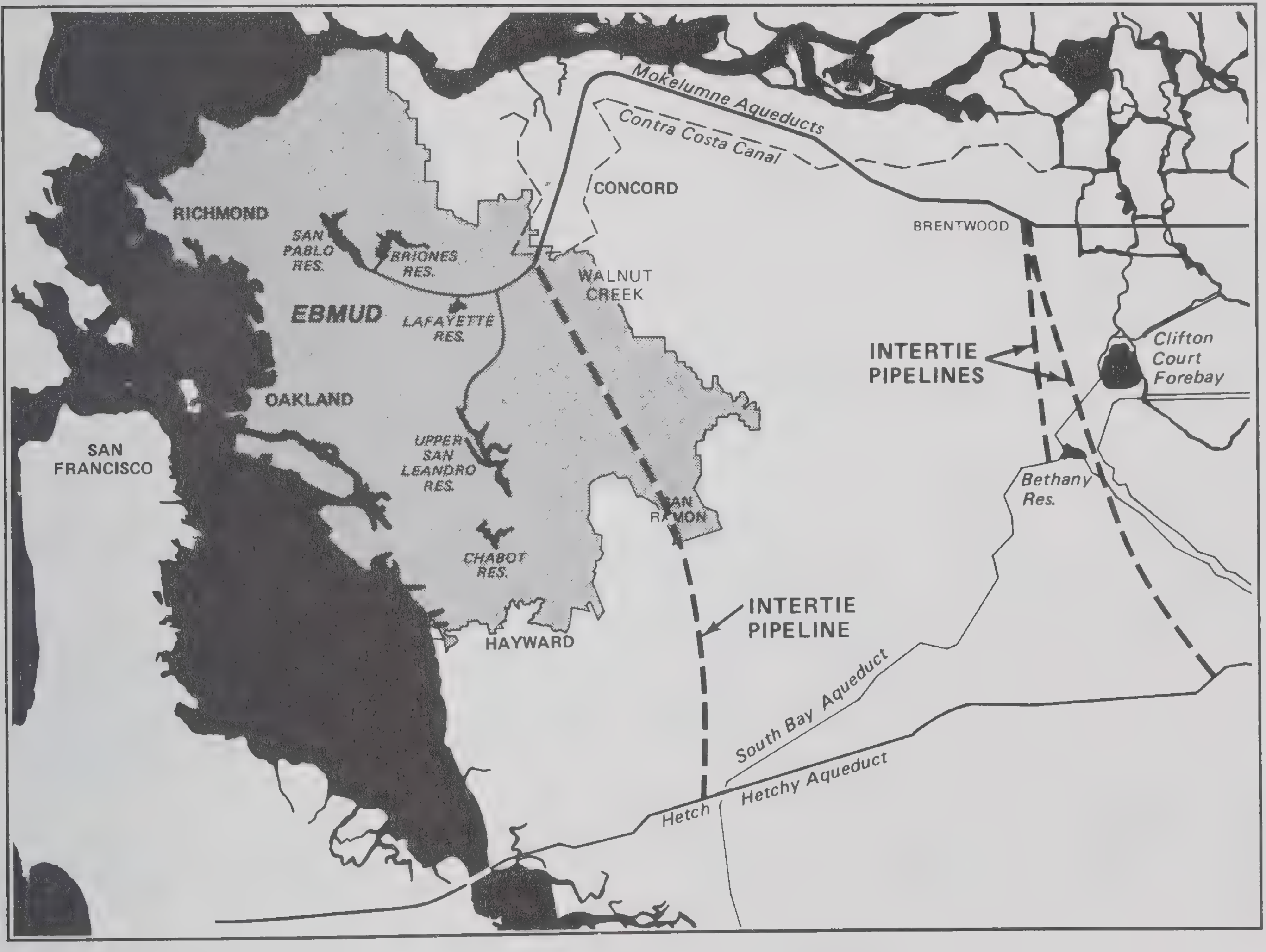
EBMUD has maintained a policy of obtaining high quality water and has not diverted water from the Delta, except in 1977. The District's 1983 Citizen Advisory Committee recommended against such diversions, and both federal and state policies urges providing water from the highest source. It would not be desirable to deliver Delta water to EBMUD customers for 13 months, given the District's present treatment capability. The cost and impact to the District's customers would be the same as the "do nothing" alternative.

Groundwater Resources

A recent report (Todd, 1986) of groundwater resources in the EBMUD service area identified two potential groundwater basins for municipal development. The potential yield from these two basins together was estimated to be 1 to 2 MGD, however, they have very poor water quality. Two potential groundwater basins are situated in the San Leandro area (East Bay Plain, South) and San Ramon Valley.

Intertie Alternative

Figure II-24



Chapter III
Shortages:
Meet Dry Year Demands

EXISTING WATER SUPPLY CONDITIONS

Problem

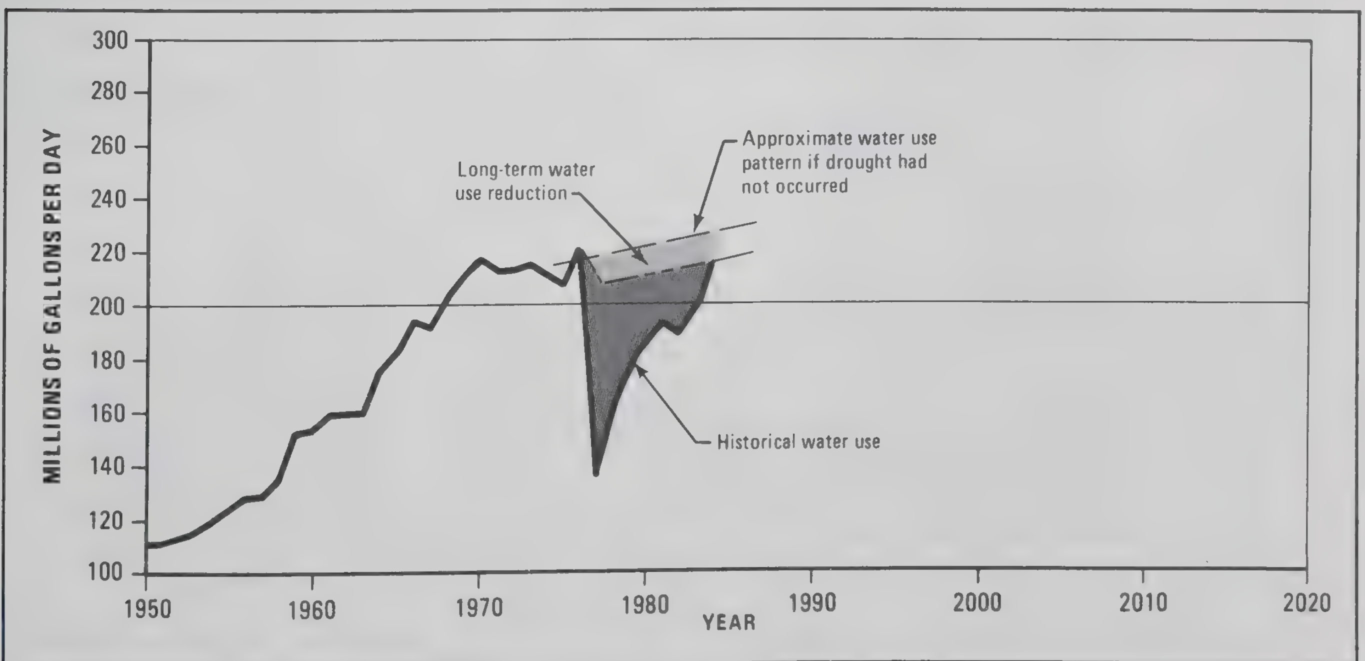
Customers are now and will experience greater hardships during dry periods, despite significant reductions in water use. There is a decreasing availability of supply as demands by other users on the Mokelumne River increase.

This chapter describes EBMUD's existing water supply conditions and discusses the ability of the existing water supply system to meet present and future demands. This chapter also identifies alternatives to solve the shortage problem described above so that EBMUD customers can continue to receive reasonable quantities of high quality drinking water.

Existing Water Demand

The 1987 level of demand in the EBMUD service area was 218 MGD, and Figure III-1 illustrates the historic water use within EBMUD. The large reduction in use in the mid-1970's reflects the effects of the 1976-77 drought. The 1975-76 and 1976-77

Historical Water Use and Effects of Water Conservation Implemented During the 1976-77 Drought — Figure III-1



runoff seasons produced the worst continuous dry period ever recorded in the Mokelumne watershed where EBMUD obtains about 95 percent of its water supply.

After the 1976 seasonal runoff, the District requested that customers voluntarily reduce water use by 25 percent. When it became evident in early 1977 that runoff would be even lower, the District imposed a mandatory water conservation program aimed at an overall 25 percent reduction in water use. In May of 1977, after analyzing the results of the final snow survey, the water supply situation became more serious, and the District imposed a 35 percent cutback for the remainder of the 1977 calendar year. Customers responded well to the conservation program, and on the whole came up with a larger reduction in use (about 39 percent) than was expected.

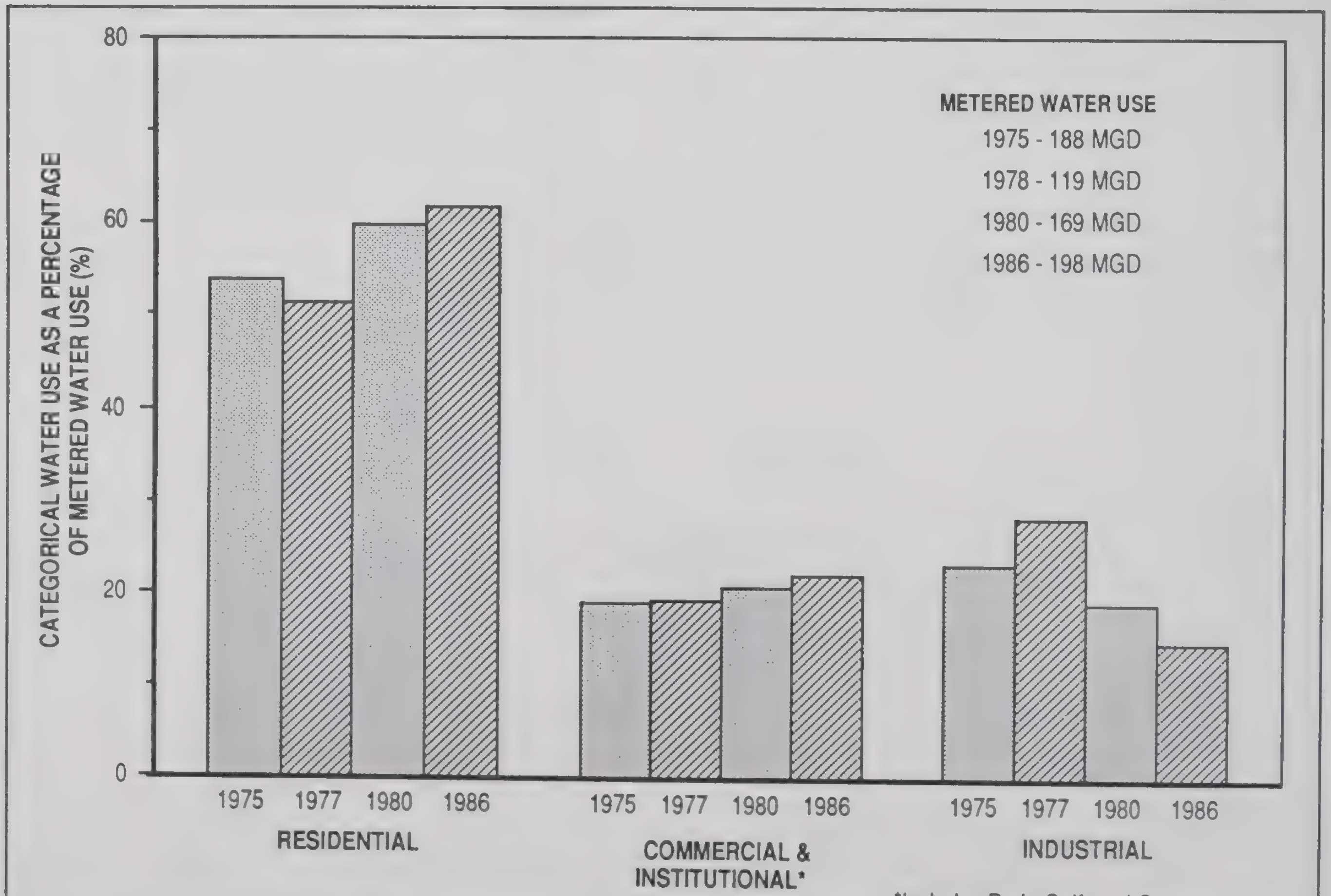
In the years following the drought, water use remained below the pre-drought (1975) level of 208 MGD and has just recently returned to that level, although with an increased number of customers. Figure III-2 shows that, while much of the water conservation efforts in 1977 resulted in short term reductions such as habit changes in residential use, many of the structural changes, such as industries' modifying water-using equipment, resulted in long-term water use reductions.

These long-term reductions are now reflected in the improved efficiency of normal water usage in the service area. The level of demand in 1986 was 215 MGD, only slightly higher than the level of demand in 1975 even though there are now about 35,000 more customers than there were in 1975. Figure III-1 shows conceptually the increased efficiency which can be attributed to the long-term reductions initiated during the drought.

Figure III-3 compares the per capita use of water in the District with water use data from other water utilities. The data show that per capita water use in the District is comparable to water use in other water districts and is often lower, particularly among residential customers.

Historical Water Use Characteristics

Figure III-2



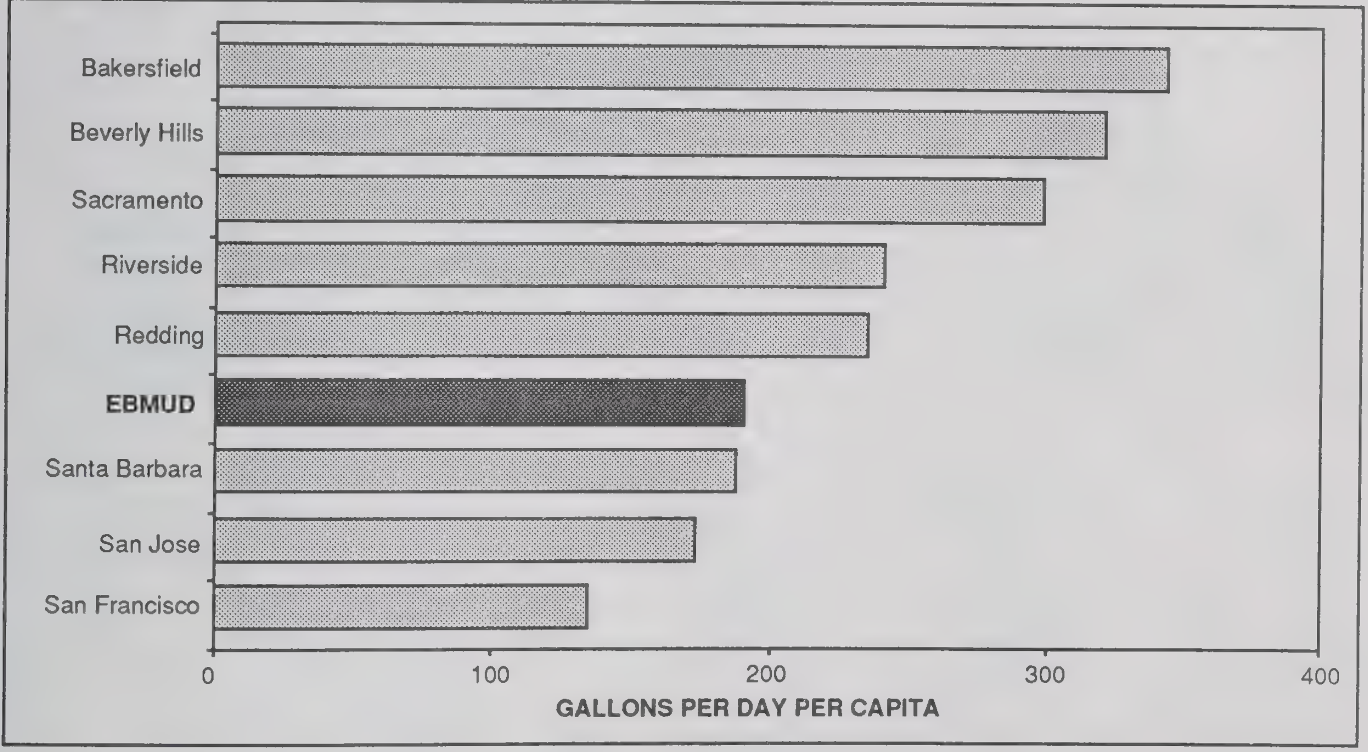
*Includes Park, Golf, and Cemetery use.

EBMUD has made detailed studies of water use patterns. This information is used for projecting future demands and identifying areas for further water conservation efforts. Figure III-4 shows a breakdown of water use into categories. Single-family water use predominates in the District followed roughly equally by multi-family, industrial, and commercial and institutional. Overall, residential water use is about 62 percent of the total metered consumption. Sixty-seven percent of all water use is inside use.

The EBMUD service area has significant variations in geographic, climatic, and land use characteristics. A review of the water use data shows that the last year of "average" water use occurred in 1981. Years since then have been either wetter or drier than normal with correspondingly lower and higher water use patterns. For this reason, 1981 residential water use data were selected for planning purposes.

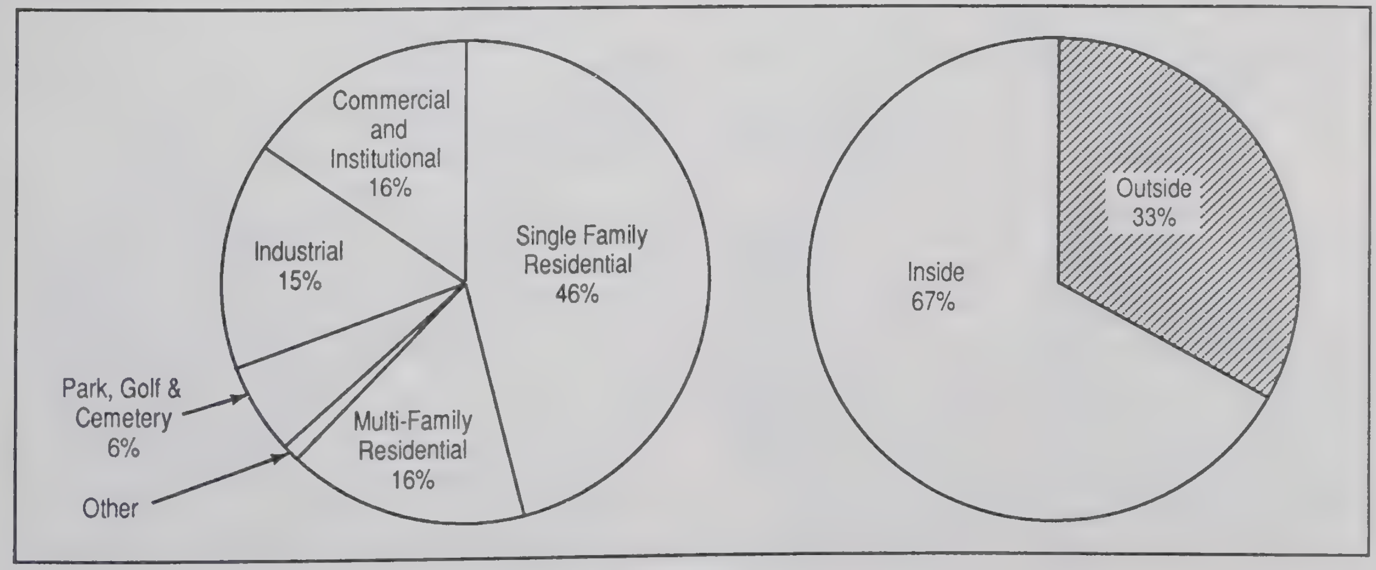
Per Capita Water Use by Selected Communities

Figure III-3



EBMUD Water Use Characteristics

Figure III-4

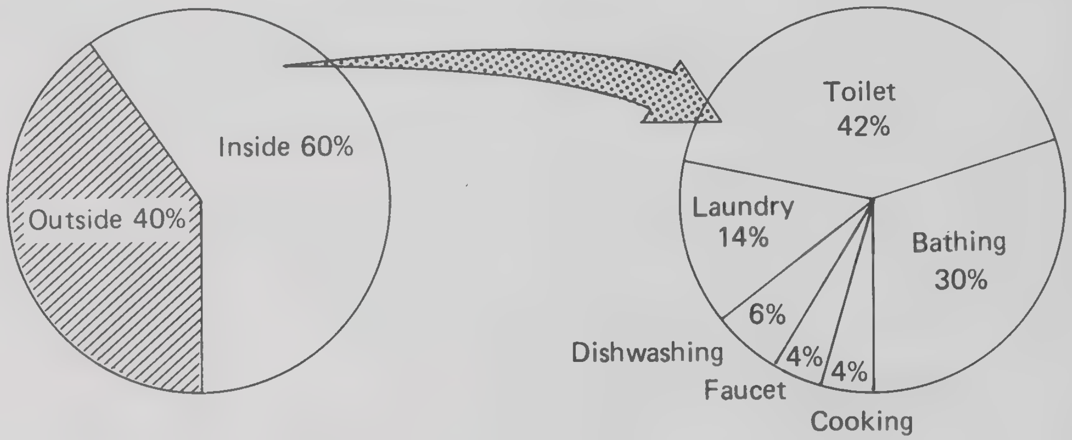


Figures III-5 and III-6 provide a breakdown of the specific types of residential uses. They show that 60 percent of the use (65 gal/capita/day) occurs inside and 40 percent of the use (43 gal/capita/day) occurs outside. Approximately 72 percent of the inside water use is for flushing toilets and for bathing. Approximately 90 percent of the outside water use is for irrigation.

The EBMUD service area has been divided into seven regions for planning distribution system facilities and for charging new customers for costs of constructing new facilities. These seven regions also define areas which have similar water use patterns due to common geographical, climatological, and land use characteristics. Figure III-7 shows inside and outside regional single-family water use in the seven regions.

Residential Water Use

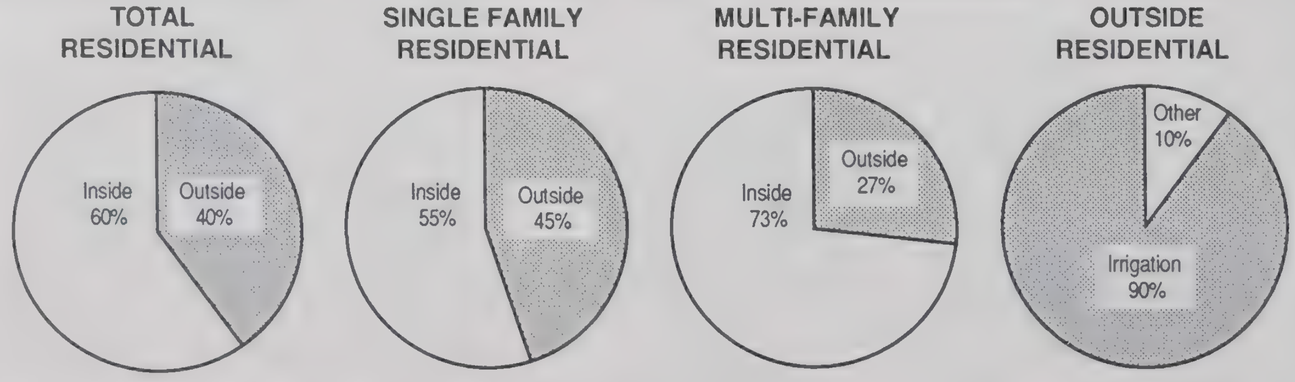
Figure III-5



Inside Water Use	Percent	Gal/Capita/day
Toilet	42	27
Bath/Shower	30	19
Laundry	14	9
Dishwashing	6	4
Faucet	4	3
Cooking	4	3
Total	100%	65

Inside and Outside Residential Water Use

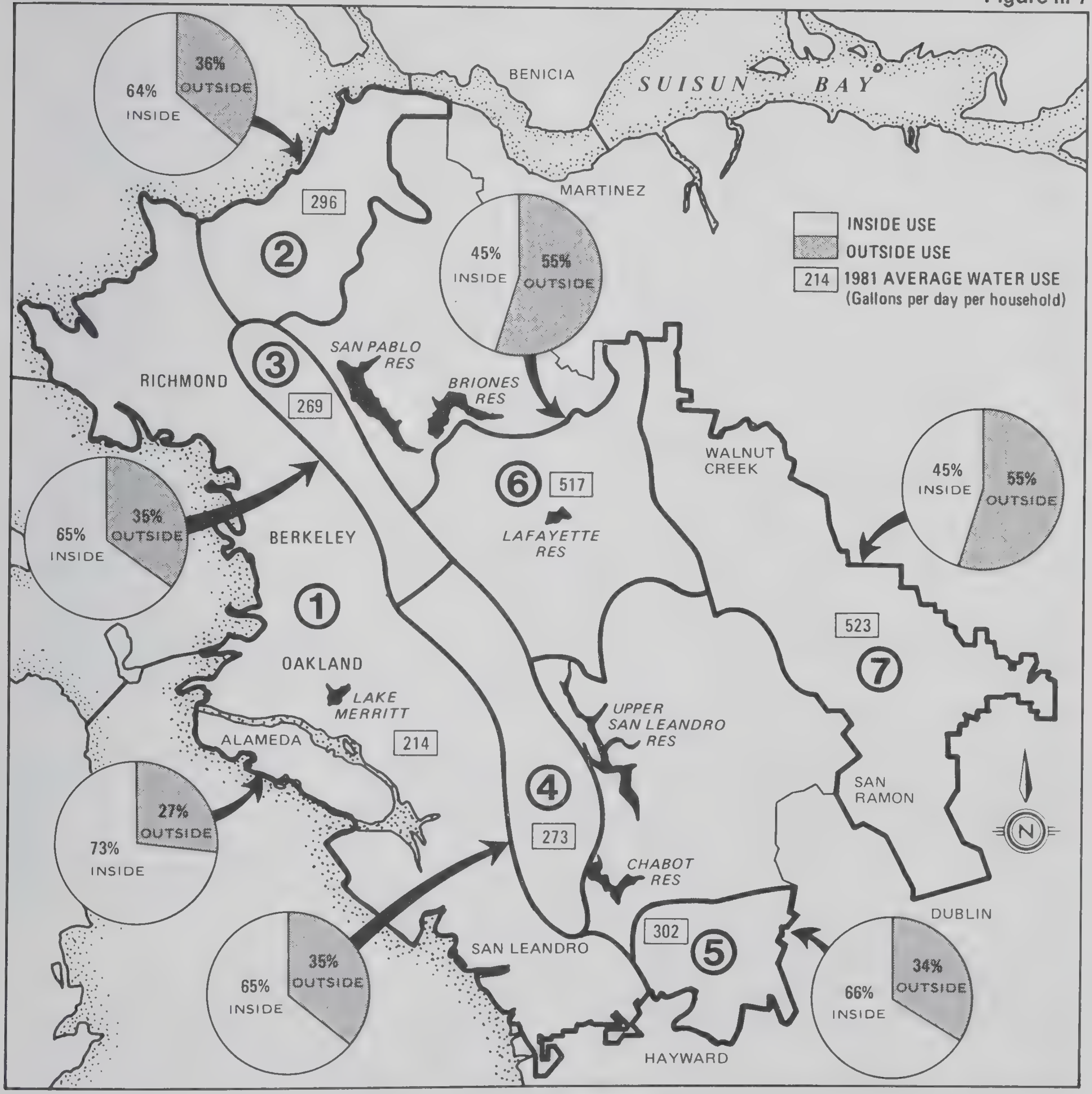
Figure III-6



Source: Urban Water Management Plan, EBMUD 1985

Single Family Residential Inside and Outside Water Use by Region

Figure III-7

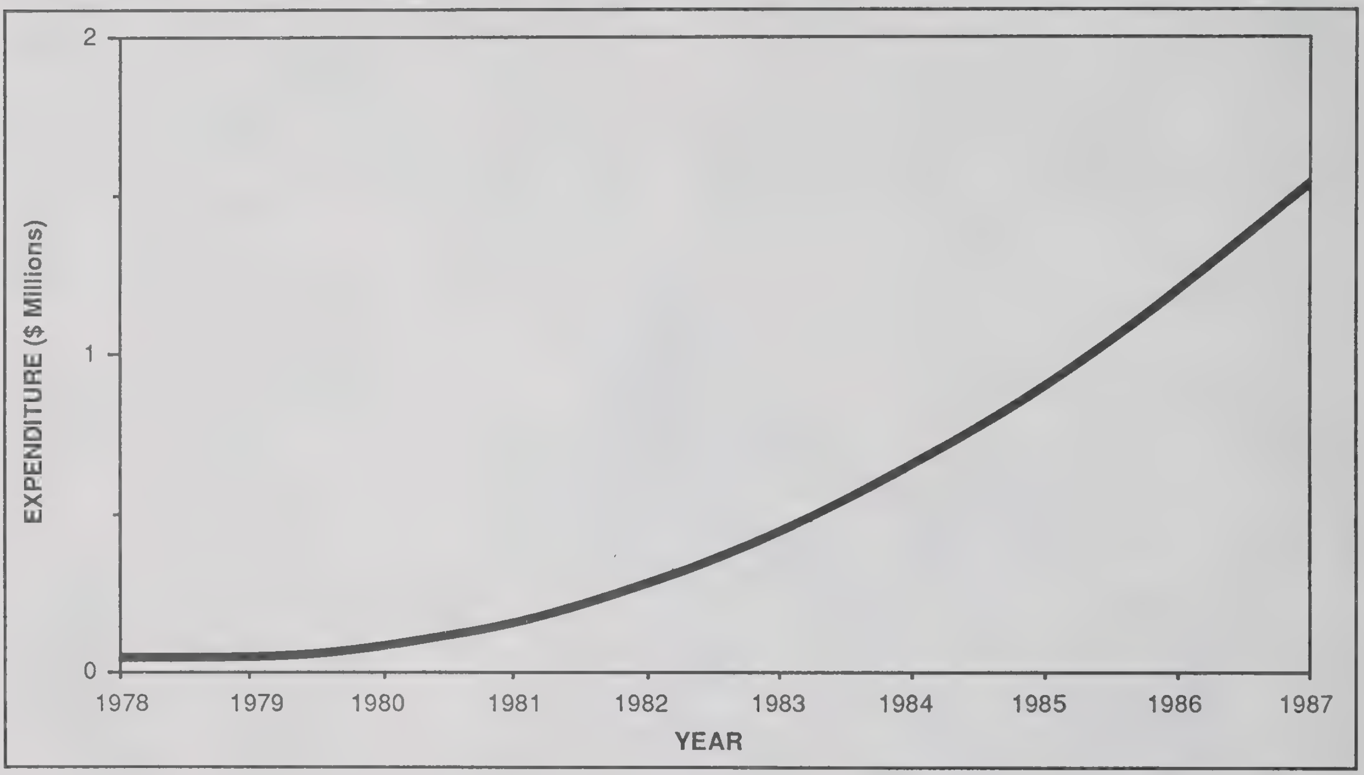


Water Conservation Activities

Figure III-8 shows the District's water conservation expenditures during the last ten years. Water conservation budgets provide for reasonable long-term and continuous efforts to improve water use efficiency and to ensure the best use of existing supplies. Short-term demand reduction measures are those actions taken in response to water shortage due to drought (1976-77 and 1987-88) or other supply emergencies. The distinction between long-term water conservation and short-term demand reduction is important in evaluating the need for, and impacts of, water conservation measures.

Water Conservation Expenditures for Past Ten Years

Figure III-8



HISTORIC WATER CONSERVATION ACTIVITIES

EBMUD has a long history of water conservation efforts. As early as 1923, water meters were required in the East Bay as a means of saving water and collecting revenue equitably. Other long standing conservation measures include public information and school education, leak detection, and pipe replacement.

Metering. District regulations require all users to be served through a meter. The requirement is enforced through continuing inspections. Occasionally illegal connections are discovered and they are immediately metered. Water use at all District facilities is also metered.

The primary purpose of meters is to assure that revenues are fairly collected. Another purpose for metering is to assure that water is used efficiently and leaks on customers' premises are discovered quickly. Nation-wide studies comparing metered water use to unmetered water use show an average reduction of 20 percent in the metered sector. In California, unmetered communities, such as Sacramento, use 50 percent more per capita than EBMUD.

In 1986, EBMUD bills began displaying present and past water use to allow customers to track use. The District also has a meter testing program to routinely test, inspect, and repair water meters, particularly meters for large water users.

Public Information. Beginning in the 1960's, when EBMUD completed the third aqueduct to the Mokelumne making its total delivery capacity 325 MGD and raising terminal reservoir storage to 155,000 acre-feet, the District began a pioneering effort in water conservation education, including school education programs that are being used nation-wide.

EBMUD's early conservation efforts were aimed at developing a long-term awareness of water and its efficient use. A series of informational materials such as brochures, bill inserts, posters, and educational publications for schools were developed. The increase in water use slowed in the first half of the 1970's, although other factors such as weather, economics, and environmental awareness undoubtedly contributed to the slowdown.

Although attempts have been made to estimate the actual quantity of water saved through various educational programs, it is difficult, if not impossible, to quantify the effectiveness of these programs. Public information and education are essential elements of a balanced conservation program in that they provide

an awareness of water and its efficient use and inform customers of opportunities to save water.

Leak Detection. Of the 215 MGD of water used in 1986, about 7.3 percent was unaccounted-for water. Unaccounted-for water is the difference between the gross quantity of water delivered to the distribution system and metered consumption (including the District's own use). The District's unaccounted-for water losses are less than one-half the national average and are decreasing.

The distribution network includes over 3,600 miles of pipe. Several techniques are used to locate leaks including visual inspections, sonic leak detection, and customer reports. EBMUD has two crews equipped with electronic sound detection equipment as part of a $267,000 annual effort.

The leak detection crews survey approximately 300 miles of pipeline per year. The estimated water saved as a result of the leak detection program ranges from 0.5 to 1.5 MGD each year. The water saved is not cumulative from year to year since it is assumed that the leaks would be discovered within a year or two even without the leak detection program. However, early detection and repair help maintain a tight water system by minimizing unaccounted-for losses. The total number of leaks and breaks repaired each year ranges from 600 to 800.

The leak detection crews also generate approximately 500 repair orders per year to repair meters and hydrants. These are not included in the water savings estimate since it is assumed that if there were no leak detection program, the leaks would be reported by meter readers as a result of their routine activities.

Several hundred door hangers are also distributed every year. These are used when leaks or open plumbing are discovered on customers' lines. The notifications are made to encourage customers to correct any problems in their plumbing. The effect of these notices is intangible and not included in the water savings estimates.

Pipe Replacement. Many conditions contribute to the deterioration of pipelines in the distribution system, including pipe type and size, soil conditions, and ground movement. Figure III-9 shows pipe type, age, and vulnerability to breaks. Because of the leak detection and pipe replacement programs, the system has a declining leakage factor. The District currently invests about $3.6 million per year towards the replacement and rehabilitation of water mains.

Records are maintained on the location and type of leaks and breaks. When a section of pipe shows a history of leaks, an analysis is performed on the benefits and costs of replacing the pipe before repairs are made. The District's goal is to replace about 7.5 miles of pipe annually. Currently, the District exceeds its goal.

Distribution System Pipe Profile

Figure III-9

PIPE TYPE	MILES INSTALLED IN SYSTEM	MEDIAN AGE (Years)	VULNERABILITY TO BREAKS* (Leaks per 100 miles)	APPROXIMATE NUMBER OF MILES REPLACED EACH YEAR
CAST IRON				
2 inch	27	45		
4 inch	322	50		
6 inch	758	46		
8 inch	208	47		
12 inch	76	40		
16 inch	25	42		
TOTAL	1416		34.5	5.5
ASBESTOS CEMENT				
4 inch	21	30		
6 inch	663	22		
8 inch	322	21		
TOTAL	1006		11.2	1.2
STEEL				
6 inch	152	21		
8 inch	152	19		
12 inch	227	19		
16 inch	114	21		
TOTAL	645		4.8	1.2

*Factors affecting vulnerability to leaks and breaks include: pipe diameter, length, age, lining, coating, year of pipe manufacture and number of breaks in past five years.

A twenty-seven year history of pipe replacement is shown in Figure III-10. During the 1960's, a major effort was undertaken to catch up with pipe replacements. This effort has stabilized at about 7 to 9 miles per year.

Corrosion Control. The distribution system is protected by 145 impressed-current cathodic protection stations and over 5,300 magnesium anodes installed on cast iron and steel mains. This program has resulted in a significant reduction in the leak of cast iron and steel pipe and saved about a half million dollars per year in leak repair costs since 1977. Internal corrosion and deposition are also controlled. Lime is added into the water system to raise the pH levels to minimize internal corrosion. Designs are carefully checked to select proper coatings, materials, and paints for all structures to prevent corrosion.

Pipe Replacement

Figure III-10

YEAR	MILES	YEAR	MILES
1961	40.18	1975	6.14
1962	25.45	1976	7.15
1963	27.39	1977	5.51
1964	27.65	1978	2.85
1965	17.65	1979	2.41
1966	23.21	1980	5.43
1967	24.68	1981	8.70
1968	25.11	1982	9.19
1969	15.24	1983	8.06
1970	13.61	1984	6.17
1971	10.20	1985	8.23
1972	10.66	1986	7.50
1973	6.34	1987	8.80
1974	8.46		

SHORT-TERM WATER USE RESTRICTION IN A DROUGHT

1976-77 Drought. The 1976 to 1977 rainfall period was the lowest of record in the service area and in the Mokelumne watershed, where EBMUD obtains 95 percent of its water supply. In June 1976, EBMUD asked customers to voluntarily cutback on water use. Worsening drought conditions in 1977 made mandatory water rationing the primary component of EBMUD's response to dwindling water supplies. In February 1977, mandatory cutbacks averaging 25 percent were imposed, but in May, each customer's allocation was decreased to a 35 percent cutback level. Figure III-11 summarizes how the cutbacks were imposed on the various customer categories. The District's priorities were to reduce water use by as much as practical and to minimize impact on businesses and employment.

Customers responded well to the mandatory program and, as a whole, reduced water use by 39 percent in 1977. Industrial and institutional customers reduced water use by installing new equipment and devices, repairing leaks, and modifying existing processes to achieve their water use goals. Many of the structural changes made by industry resulted in permanent water savings. Currently, water use by industrial customers amounts to 30.1 MGD, only 68 percent of pre-drought levels. In a future drought, these customers will be unable to reduce their demand to the extent that they did previously without causing a serious impact on their operations.

Residential and commercial customers, which account for over 75 percent of metered water use, installed water saving devices in toilets and showers, recovered

Rationing Imposed During 1976-77 Drought

Figure III-11

	CATEGORY OF USE	25% OVERALL REDUCTION FOR 1977 Imposed Feb. 8, 1977	35% OVERALL REDUCTION FOR 1977 Imposed May 1, 1977
ALLOCATION	Single Family Residential — Family of three	280 gpd*	225 gpd
	Each additional person	60 gpd	35 gpd
	Multiple Family Residential	30%	35%
REDUCTION FROM PREVIOUS YEAR	Commercial	25%	30%
	Institutional	25%	30%
	Industrial	10%	20%
	Non-Residential Irrigation	50%	60%

*Gpd is gallons per day.

bath water for garden use, or drastically reduced or eliminated landscape irrigation. Ceasing landscape irrigation caused substantial loss of lawns, shrubs, trees, and property value to many customers. The cost of replacing landscapes lost during the drought has been estimated to be approximately $75 million. Residential and commercial customers saved water mainly through reduced irrigation. However, as landscapes were replaced and water saving habits faded, water use increased. By 1980, water use for residential and commercial customers had reached pre-drought levels.

Between 1975 and 1985, population increased by about 52,000 people or 5 percent. During that same period of time, the number of residential accounts increased by 8.7 percent, and the number of non-residential accounts increased by 13.9 percent. Since 1975, per account water use for non-residential customers has decreased by 15 percent, while per capita residential water use has increased by 11 percent.

1987-88 Drought. Following a critically dry winter of 1986-87 in the Mokelumne watershed, the District embarked on a voluntary demand reduction program in an attempt to get customers to reduce their water use by 12 percent over the previous year's level. This effort was necessary to minimize the risk and magnitude of water supply deficiency in 1988 should this year prove to also be dry.

The short-term measures implemented in 1987 are shown in Figure III-12. The cost of this effort was $550,000. Customer response to dry conditions was less than the 12 percent reduction requested. It is estimated that water use was only 5 percent less than it would normally have been considering weather conditions during the summer of 1987. The reason for this, it is believed, is that customers did not perceive a serious drought condition to exist. However, water supplies remain low and rationing is under consideration for 1988.

These data indicate that non-residential customers, particularly industrial and institutional customers, have become more efficient in their water use, partially because of permanent changes made during the 1976-77 drought. However, residential customers now use more water than prior to the drought. This trend is important to consider in evaluating demand reduction measures during a future drought. Non-residential customers are now operating more efficiently and will

1987 Demand Reduction Program (May through December)

Figure III-12

CONSERVATION WORKSHOPS

District conducted eleven workshops for public agencies and large irrigators to provide information on landscape irrigation requirements and scheduling.

WATER USE REDUCTION REQUEST LETTERS

Postcards requesting water conservation were sent to all customers in May 1987. Letters requesting conservation were sent to 7,000 large irrigators.

LAWN WATERING CONSERVATION GUIDES

Guides describing the amount and timing of lawn watering were sent to 282,000 customers.

CONSERVATION EDUCATION IN PUBLIC SCHOOLS

Water conservation information including bumper stickers, diamond signs, magnets and other material were distributed to students in June and September of 1987.

RADIO ADS AIRED DISTRICT WIDE

A total of 666 radio spots were aired on ten radio stations through September 1987.

CONSERVATION PLACARDS ON PUBLIC TRANSPORTATION

Water conservation placards were placed on 210 AC Transit buses and 30 placards were placed at BART stations.

WASTE WATCHERS

Twelve summer employees patrolled the service area looking for water waste. Waste watchers would alert customers of waste and provide conservation information. Four employees have been retained for the winter.

not be able to reduce water use as they have previously without experiencing greater consequences.

In March, 1988, EBMUD's Board of Directors authorized $300,000 in funds to prohibit the wasteful use of water, increase public awareness of the water shortage, and notify agencies outside of EBMUD's service area of the District's intent to cut off service.

LONG-TERM WATER CONSERVATION

Demonstration Gardens. A landscape water conservation demonstration garden pilot project was started in 1981 to retrofit three residential front yard gardens. It demonstrated the attractiveness and benefits of low water use and low maintenance drought-tolerant landscaping in Berkeley, Lafayette, and Moraga. The front yards were landscaped by three different landscape architects to show a variety of ways to work with drought tolerant plants.

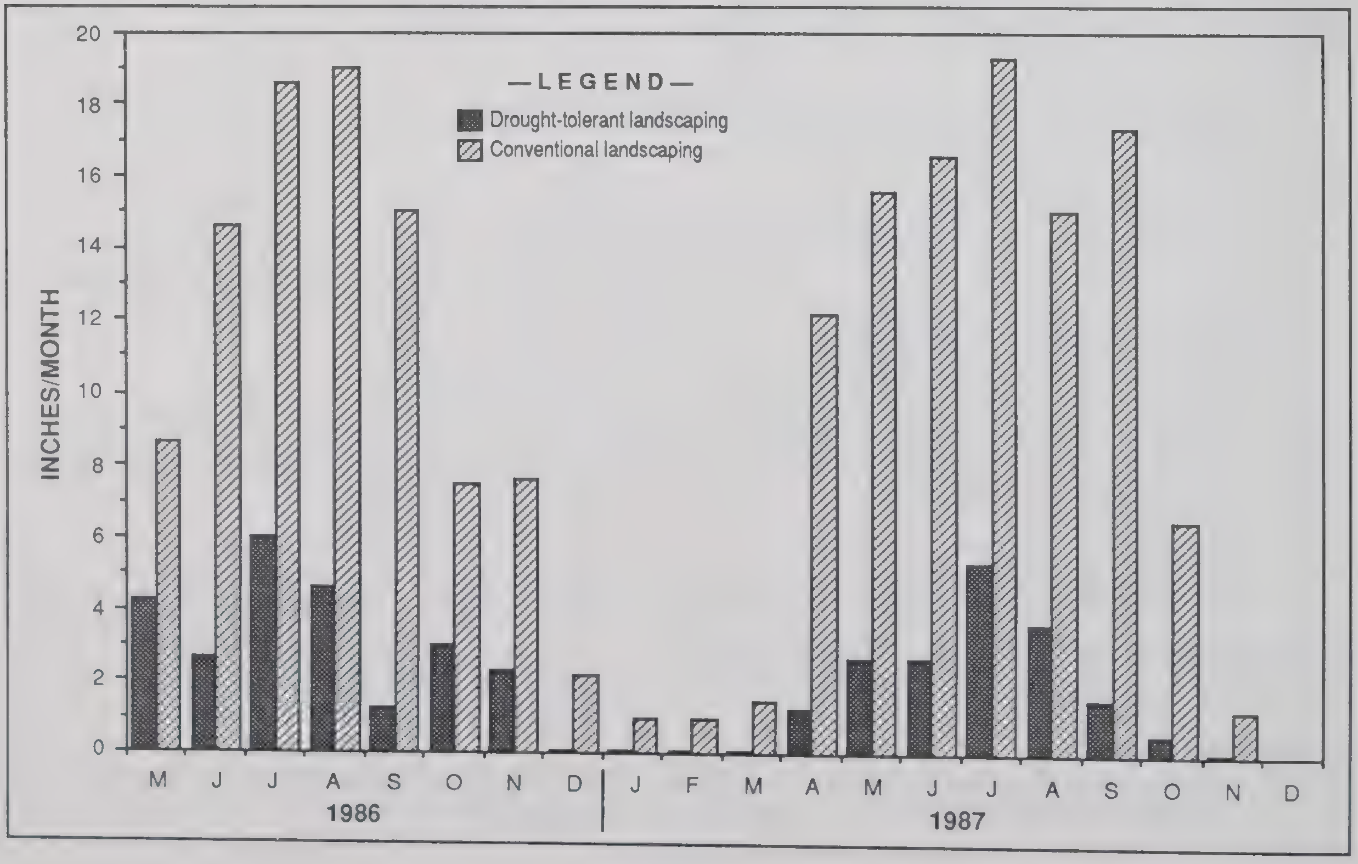
The garden installations were completed in October 1983. Even though 1984 was hotter and drier than normal, causing demand to rise approximately 10 percent District-wide, water use for the demonstration gardens dropped nearly 45 percent from the previous four-year average. Once fully established, the demonstration gardens have shown that outside water use can be reduced by up to 90 percent by replacing lawns with low water landscapes. These gardens were developed and tended under controlled conditions, but the potential for water savings is significant although some objections to their appearance were noted.

The gardens have been publicized since the spring of 1985 through newspaper articles and other media channels. The homeowners keep weekly logs of the time they spend on weeding and other maintenance and monitor water use. EBMUD plans to continue to monitor and evaluate the demonstration gardens for several years.

In addition, a Resource Garden, installed at Lake Merritt in Oakland in 1982, is part of a cooperative effort between EBMUD, the City of Oakland, the State of California, and the U. S. Environmental Protection Agency. The garden is a demonstration site showing the use of composted sewage sludge, low water using plants, and efficient irrigation systems.

Additional demonstration gardens built with the cooperation of other public agencies include: landscaping at the District's Alamo business office, a traffic median in the City of Danville, and a 20,000 square feet garden at Heather Farms park in Walnut Creek. Figure III-13 shows the water savings achieved

Alamo Demonstration Garden Water Use **Figure III-13**



at the Alamo demonstration garden site. Currently, the District is working with the City of Alameda and the City of Oakland to establish additional demonstration garden projects.

The District typically contributes $5000 to $10,000 to each garden and provides technical and design assistance. New gardens are constructed at the rate of about two per year.

Water Pricing. Water pricing is frequently suggested as a way to reduce excess water use. If water pricing influences water use in the United States generally, or in EBMUD specifically, it has not been demonstrated by any current statistical techniques. The reason for this is that the total cost of water to the average residential user is very small.

In 1983, the District adopted an elevation surcharge that increased the costs to water users at higher elevations by 30 to 50 percent in two different areas. To date, there has been no statistically demonstrable difference in water use in these areas. (See Figure III-14.) However, if significant increases are also applied at the same time during rationing when there is a general public awareness of shortage, there may be a combined effect.

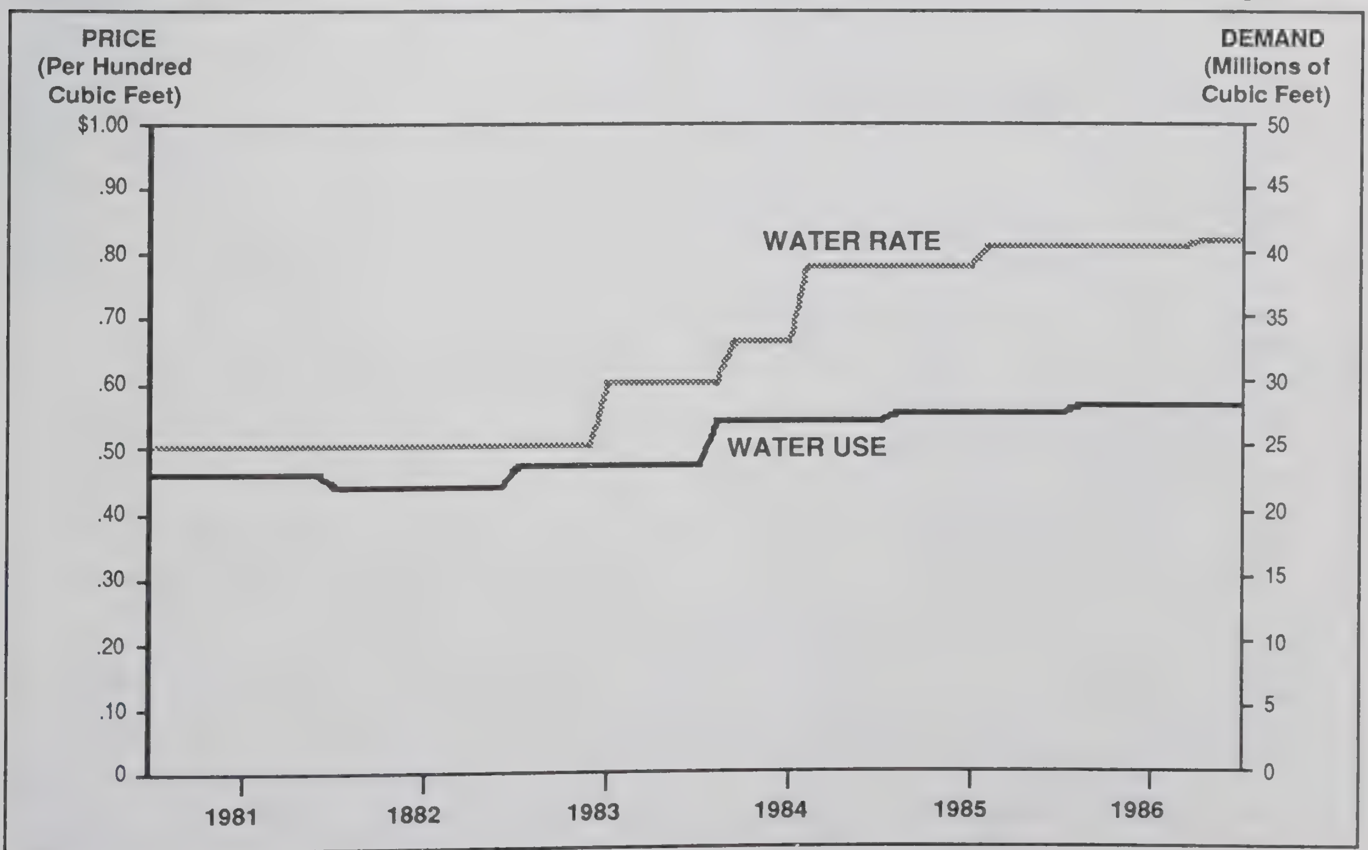
In the drought of 1976-77, it was difficult to determine whether the public perception of the drought or the dramatic rate increase (100 percent excess use charge for use over the allotment) was more effective in reducing demand. Clearly the combined effect was significant. Therefore, pricing has been considered a demand reduction measure as part of a short-term drought management program.

URBAN WATER MANAGEMENT PLAN

In 1985, in response to the Urban Water Management Planning Act (AB 797), which was sponsored by EBMUD, the District prepared its first Urban Water Management Plan. That plan identified a series of water conservation measures, which are shown in Figure III-15. The following is a discussion of the current status of implementation of the plan's activities.

Water Saving Device Distribution. In 1986, the District distributed 5,000 retrofit kits, which included a 2.75 gpm low-flow showerhead and toilet dams to save 0.5 gal/flush, to hotels, motels, apartments, and other planned multi-unit developments. The District has been monitoring water use by these customers;

Price vs. Demand Elevated Zones Figure III-14



Urban Water Management Plan Water Conservation Program

Figure III-15

WATER CONSERVATION MEASURES	IMPLEMENTATION STATUS		
	FULLY IMPLEMENTED	PARTIALLY IMPLEMENTED	NOT YET IMPLEMENTED
A. WATER SAVING DEVICE DISTRIBUTION Offer 20,000 retrofit kits (first year) at EBMUD business offices and through water audits including low-flow showerheads and water bags for toilets to increase the number of water-saving devices installed in single and multi-family residences as well as commercial, institutional* and industrial premises.	X		
B. WATER AUDITS Offer to inspect water-use practices of existing industrial, commercial, institutional and single and multi-family residential customers and make recommendations for improved efficiency. Offer retrofit kits where applicable. Primary focus will be on indoor and process water use.		X	
C. LANDSCAPE CONSULTATION Introduce all existing and new customers to low water-using landscape concepts and materials through mailings and personal contact. Customers will be offered technical assistance and District literature.		X	
D. LANDSCAPE REBATE Offer a rebate to existing customers to provide an incentive to install water-conserving landscapes that meet District criteria (single family up to $300 and multi-family up to $5000, based on landscaped area).			X
E. SYSTEM CAPACITY CHARGE (SCC) Offer discounts on the SCC paid by all new customers who exceed code requirements for showerheads and toilets.			X
F. LANDSCAPE WATER USE EFFICIENCY IN NEW DEVELOPMENTS Establish landscape water-use efficiency regulations for new residential, industrial, institutional and commercial developments through cities and counties or by the district, if necessary; or Offer incentives to install water-conserving landscapes that meet District criteria through an SCC discount or rebate program.		X	
G. PUBLIC INFORMATION Provide public information programs such as landscape booklets and brochures, exhibits, etc. to support and promote water conservation by demonstrating the methods for conserving water and the benefits of efficient water use.	X		
H. SCHOOL EDUCATION Increase the promotion of wise water use habits and expand appreciation for water as a limited natural resource in primary and secondary schools.	X		
I. SUPPORT ACTIVITIES Establish a Landscape Advisory Committee to provide technical support and act as liaison with the professional landscape community.			X
J. DISTRICT WATER USE ACTIVITIES Develop procedures to review District landscaping plans and retrofit existing District landscape to assure efficient water use.	X		
K. WATER PRICING STUDY Study water conserving rate structures as a means of increasing water use efficiency.	X		
L. PRESSURE REDUCTION STUDY Identify areas of high water pressure (greater than 80 psi) and investigate the feasibility of a pressure reduction program.			X

*Institutional includes public agencies.

however, it is too early to tell how much water is being saved.

In 1987, the District purchased 17,000 kits for $50,000; 12,000 retrofit kits were made available to customers through the District's business offices. In January 1988, District staff distributed 5,000 kits door-to-door to customers in selected areas. The District will monitor the water use of these customers and follow-up with surveys to determine customer satisfaction with the devices.

The most recent kits include showerheads with flow rates between 1.8 gpm and 2.7 gpm. If these kits are installed in housing units built prior to 1978, there is a potential for savings of about 9.8 gal/capita/day. This is currently equivalent, on average, to 27.1 gal/day for single family homes and 18.6 gal/day for multi-family developments. However, since 1978, California law has required new housing to include low-flow showerheads (2.75 gpm) and low-flush toilets (3.5 gal/flush). Therefore, the showerheads included in the kits will save little additional water (about 3 gal/capita/day) in homes built since 1978.

Another factor to consider with the retrofit kits is that not all the kits distributed are actually installed. Furthermore, some devices may later be removed due to dissatisfaction. The District is currently evaluating the rate of use and satisfaction with retrofit devices distributed to customers.

Water Audits. The water audit program was implemented in 1987. The purpose of the program is to examine water use practices, detect leaks, and make recommendations for improved efficiency for both inside and outside water use. Approximately 100 audits have been conducted, mostly for commercial customers, multi-family residential housing, and other planned unit developments.

The District plans to conduct 300 audits per year, keeping track of customers who receive audits and monitoring their use for water savings. Future analysis will determine if the audits performed to date have been effective in reducing water use.

Landscape Consultations. The District offers free landscape consultations to familiarize customers with low water use landscapes and associated benefits and to provide technical assistance. During the consultations, the District will review landscaping plans, recommend plant material, and provide information on irrigation. Approximately 50 landscape consultations were conducted in 1987, half with multi-family residential and other planned unit developments and half with single family residential customers, including homeowner associations.

Landscape Rebate. This measure has not been implemented, however, a pilot rebate program is proposed as part of the alternative water conservation program discussed later in this chapter.

System Capacity Charge (SCC) Discount. This measure has not been implemented. See discussion in Appendix A.

Landscape Water Use Efficiency in New Developments. In August 1987, the District imposed stringent landscape design criteria on three annexations to the District's service area. These developments will be required to conform to the landscape guidelines as a condition of water service. Shortly before that time, the District provided the cities and counties within the EBMUD service area with "model" guidelines establishing criteria for landscapes in new developments. The guidelines include criteria on reviewing landscape plans, limiting lawn areas, types of plant material, and irrigation systems. The guidelines are intended to reduce outside water use by 25 percent in affected new developments; however, the actual savings are uncertain. Contra Costa County and the cities of Albany, Danville, El Cerrito, Piedmont, Pinole, and San Leandro have adopted modified versions of the guidelines. The District is continuing to encourage other cities to adopt similar guidelines.

As a practical matter, the guidelines have yet to be adopted and enforced District-wide.

Public Information. The following is a list of public information material designed and produced by the District.

- Landscape Book. In 1986, the District produced 10,000 copies of a 100-page book with color photos describing water conserving plants and landscapes of the Bay Area. The cost was $80,000. The books are available to the public for $8.00.
- Landscape Brochure. In 1987, the District produced 150,000 copies of a landscape brochure which identifies low water using plants. The brochure cost $20,000 to produce and is available to customers for free.
- Landscape Video. The District is currently working with other agencies to produce a landscape video to provide tips on low water using landscaping.

- Exhibits. The District has two portable water conservation exhibits which are displayed in public buildings, at community events, and at conferences.

- Speakers Bureau. EBMUD provides speakers from its staff to give 50 to 100 presentations each year on water conservation and other topics.

- Water Conservation Activity Center. In September 1986, a Water Conservation Activity Center was established at the Alamo business office. The center includes a demonstration garden, a conservation exhibit, and provides information on water saving devices and low water using landscapes.

School Education. EBMUD has been involved in the development of educational material since the early 1970's. EBMUD has helped in the development of educational software which will teach students about water and its efficient use.

Support Activities. The District has hired landscape architects to assist in the development of landscape guidelines, conduct landscape consultations, review landscaping plans, and advise customers on irrigation systems.

District Water Use Activities. The District currently meters its own water use at all facilities. In addition, all landscaped areas of District facilities are now planted with low water using plants, and the District is currently formulating specific criteria for landscaping at District facilities.

Water Pricing Study. In 1987, the District conducted a water pricing study to evaluate the effects of price on water demand. The study found no statistically significant relationship between price and water use. The study examined water use by customers within the service area whose water rates increased from 30 to 50 percent with the imposition of an elevation surcharge in 1983.

Pressure Reduction Study. The District has not yet conducted a study to identify areas of high water pressure (greater than 80 psi) and investigate the potential feasibility of a pressure reduction program.

IRRIGATION UPGRADE PILOT STUDY

The District has collected data concerning the water savings in its demonstration gardens due to efficient irrigation and water conserving plant material. However, water savings resulting from irrigation systems upgrades is presently unknown. In 1988, the District plans to conduct an irrigation upgrade pilot study in cooperation with other public agencies. By studying the irrigation practices of the 100 largest irrigators, the District will determine landscape water efficiencies and analyze potential benefits from incentive/rebate programs. The 100 largest irrigators comprise approximately 7.5 percent of District outdoor use.

Several studies will be conducted during the course of the pilot program to determine the feasibility, method, and costs and benefits of an incentive/rebate program. The studies will:

- Determine potential water savings and cost effectiveness of upgrading existing automatic irrigation systems.

- Evaluate the current water use practices of the District's 100 largest irrigators to determine what improvements, if any, can be made.

- Compare potential landscape irrigation savings of single family households with non-single family customers.

Water Reclamation

Reclamation is the process of collecting and treating wastewater to produce water of suitable quality for additional beneficial uses. In California, approximately 240 water reclamation plants serve over 380 users with 65 billion gallons of reclaimed water per year. Of this amount, 80 percent is used for agricultural and landscape irrigation, 11 percent for groundwater recharge, 4 percent for industrial cooling and washdown, 3 percent for recreational impoundments, and the remainder for miscellaneous activities such as dust control.

Over the past several years, the District has been investigating the feasibility of wastewater reclamation as a way to make the most efficient use of the high quality Mokelumne River supply, adding to its long-term supply. The result has been the implementation of programs that currently save approximately 4.7 million gallons per day (MGD) of potable water per year. These programs are summarized in Figure III-16. Several additional projects are currently proposed to increase this amount by another 4.9 MGD over the next several years, and are discussed in a later section.

Reclamation Projects

Figure III-16

PROJECT	DESCRIPTION	STATUS	ANNUAL WATER SAVINGS (MGD)
EBMUD Wastewater Treatment Plant	Reclaimed wastewater for landscape irrigation and general washdown at the facility.	Standard practice	0.54
	Secondary effluent used for industrial cooling of power generation station and cooling of compressors at oxygen production plant.	Standard practice	1.5—2.0
EBMUD Filter Plants	Reclaimed backwash water from District filter plants.	Standard practice	7.0
Richmond Golf Course	Reclaimed wastewater from West Contra Costa Sanitary District for irrigation of the Richmond Golf and Country Club.	Service started in 1984	0.16

CURRENT WATER RECLAMATION PROJECTS

EBMUD Wastewater Department Activities. In 1971, the District constructed the Process Water Plant at its Wastewater Treatment Plant to provide tertiary treatment of wastewater for on-site irrigation and plant washdown uses. This plant has a capacity to treat up to 1 MGD. The average annual production is 0.54 MGD (605 acre-feet/year). Additionally, secondary effluent is used for industrial cooling of the power generation station and for cooling of compressors at the oxygen production plant. The quantity of secondary effluent is on the order of 1.5 to 2.0 MGD (1680 to 2240 acre-feet/year).

Filter Plant Washwater Reclamation. Facilities for reclaiming filter backwash water from most of the District's filter plants were constructed in the late 1970's in order to comply with federal discharge requirements. The National Pollutant Discharge Elimination System (NPDES) permit required that the majority of suspended solids be removed from the washwater prior to discharge into a receiving stream. The treatment plants operate sedimentation facilities to collect the solids and recover the clarified overflow. Four of the six plants recycle the overflow through the normal treatment process rather than discharging it to the receiving stream. The operation of filter plant reclamation facilities saves the District approximately 2.0 MGD (2240 acre-feet/year). The ability to treat and reclaim about 5 MGD (5,600 acre-feet/year) of washwater at Orinda filter plant will be available in 1988; however, because direct discharge of washwater to the San Pablo Creek replenishes the San Pablo Reservoir no additional water savings will be realized. Facilities currently under construction at Orinda will allow reclaimed water to be used at the filter plant. Although normal discharge will be to the creek.

Richmond Golf Course. In 1984, the West Contra Costa Sanitary District (WCCSD) began supplying reclaimed wastewater for summertime irrigation to the Richmond Golf and Country Club. One hundred and fifty acres are irrigated, resulting in an estimated average annual consumption of 0.16 MGD (185 acre-feet/year). Peak monthly use during the irrigation season has reached 0.61 MGD. As water purveyor, EBMUD was instrumental in implementing this project and is responsible for overseeing its operation.

The economic incentive for the user to switch to reclaimed water was a significant factor in the decision to proceed with this project. The user pays a small amount for operation and maintenance of the reclaimed water system (pumping, coliform monitoring, and reporting) and for the backup potable water supply, which is always available. The wastewater also provides all the fertilizers needed to promote turf growth. The cost to the user averages approximately $45/acre-foot. At this price, the District is reimbursed for all costs.

Factors contributing to the relatively low cost of this particular project are the close proximity of the wastewater treatment plant (two miles) and the availability of an existing abandoned pipeline, which is used for most of this distance. In addition, the high quality of WCSSD effluent and the reliability of the treatment processes at this plant ensure that the reclaimed water meets Department of Health Services (DOHS) coliform standards for irrigation use with no additional treatment, although a standby chlorination unit is immediately available.

POLICY ON THE SALE OF RECLAIMED WATER

In the past, the District addressed the pricing of reclaimed water on an individual project basis. This was because each project is unique in terms of its source, treatment requirements, and the District's role in project implementation.

Because reclaimed water is more expensive (2-3 times the cost on a unit basis of new projects), the District's Water Conservation and Development Fund made up of revenues taken from new connections will finance these projects. The fund was established by EBMUD to assist in the financing of measures to increase water supply availability. This fund may be used to implement water conservation measures or develop wastewater reuse or water supply improvement projects. This approach is consistent with the recently adopted policy on the sale of reclaimed water shown in Figure III-17. The policy provides a standardized approach for setting a price for reclaimed water based on the unique water quality and operational factors of each project. The primary goal is to recover District cost to the extent without increasing the overall cost to the user. The reclaimed water policy also states that when reclaimed water is available, and suitable for use, it should be substituted for potable water in non-potable applications.

Policy on Sale of Reclaimed Water

Figure III-17

IT IS THE POLICY OF THE EAST BAY MUNICIPAL UTILITY DISTRICT TO:

Maximize the efficient use of the existing potable water supply system by supporting the development of reclaimed water projects.

Establish a reclaimed water price that will:

1) generate sufficient revenues, when combined with connection charge revenues, to recover all District costs over the life of the project,
2) result in no net increase in the overall cost to the user for water, and
3) be a fixed percentage of potable water cost, allowing for inflationary increases over the life of the project.

Substitute reclaimed water, when available, for potable water in non-potable applications (irrigation, process cooling, etc.)

AVAILABILITY OF SUPPLY

The District has the legal right and capacity to divert up to 325 MGD from the Mokelumne River, an amount available in most years.

Supply Limits

Conditions which restrict the District's ability to use its legal right of 325 MGD include:

- Upstream water use by prior rights holders.
- Downstream water use by riparian and senior appropriators and other downstream obligations.
- Drought, or less than normal rainfall.
- Emergency outage.
- Achievable demand reductions during reduction/loss of supply.

These conditions which restrict the supply available from the Mokelumne are illustrated in Figure III-18.

Demands on the Mokelumne River

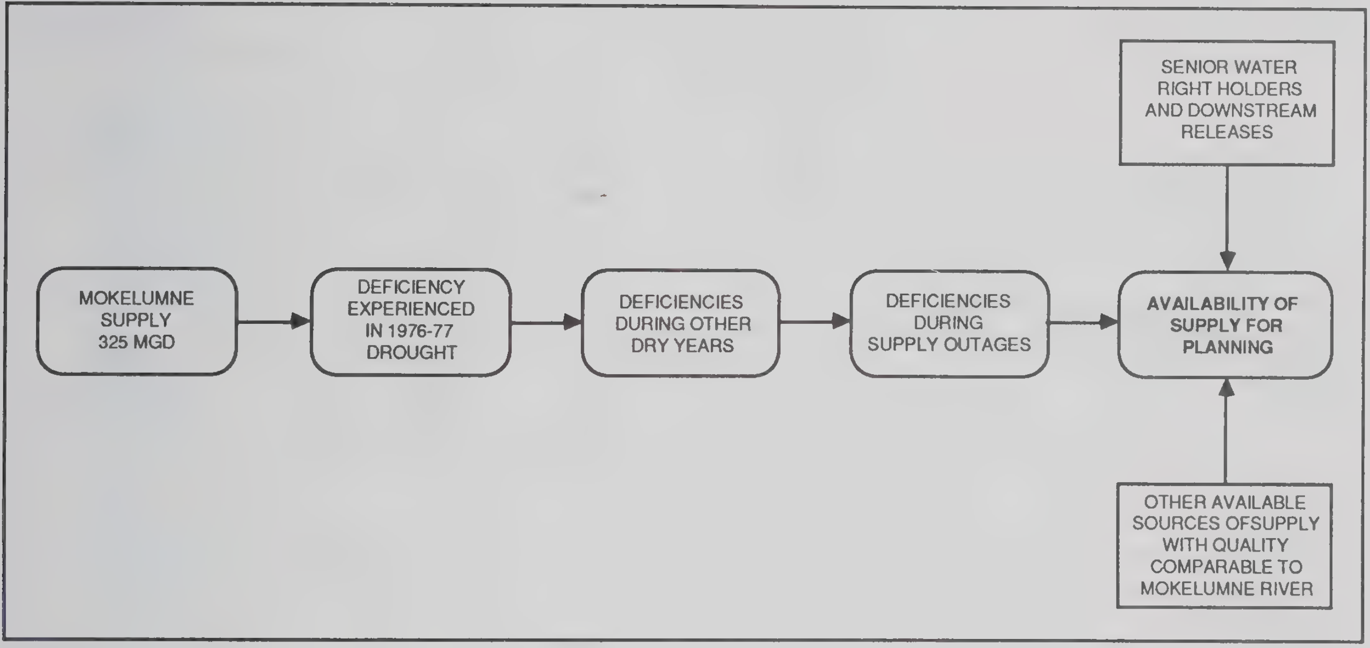
EBMUD's water supply from the Mokelumne River is subject to the water rights of other users. The District's position in the hierarchy of Mokelumne water users is determined by a variety of agreements between Mokelumne right-holders, as well as by the appropriation permits and licenses which have been issued, pre-1914 rights and riparian rights. Figure III-19 shows the hierarchy or relative priorities of rights and other flow commitments on the lower Mokelumne basin. Demands on the Mokelumne River by prior rights holders and riparian rights are anticipated to increase by the year 2020 thereby reducing the firm yield of the District's Mokelumne supply. The firm yield of the District's Mokelumne supply is defined as the maximum continuous rate of diversion that can be derived from the project through the most critical period of record by making maximum use of available storage. The firm yield of the District's Mokelumne supply system is projected to decline from 215 MGD to 198 MGD.

Drought

In most years, the full 325 MGD allotment is available. However, during drought periods of two or more years, the delivery of water from the Mokelumne can be as low as 198 MGD. As discussed later in this chapter, demand is projected to increase from the current 220 MGD to 270 MGD in 2020, and the firm yield is projected to decline from 215 MGD to 198 MGD at the same time. When demand

Conditions Restricting Supply

Figure III-18



exceeds the firm yield, the District must impose mandatory rationing unless adequate backup storage is available. In 1985, the District responded to the increasing risk of shortage by adopting a Water Supply Availability and Deficiency Policy.

POLICY ON WATER SUPPLY AVAILABILITY AND DEFICIENCY

Because of the drought situation in 1977, the District adopted a policy on Water Supply Availability and Deficiency in May 1985. It recognized that planning on taking a deficiency in the water supply during drought is a prudent approach because (1) such deficiencies are infrequent, (2) the magnitude of the deficiencies and thus the hardship on customers can be limited, and (3) it allows the supply to be put to a greater beneficial use in most other years when the full entitlement of 325 MGD is available from the Mokelumne River.

The policy established criteria for evaluating the adequacy of the District's water supplies and to provide for the following:

- Annual review of the water supplies available for the current and following year to meet the demand of EBMUD's customers.
- Annual review of the water supplies available for the long-term to meet projected increases in demand.
- Case-by-case review of the water supplies available when considering decisions on requests for extension of service to annexations beyond the ultimate boundary and replacement supplies to other water agencies.

The availability of the Mokelumne supply to customers is dependent on a large part to (1) the timing and severity of rationing imposed upon customers during a drought or outage and (2) the amount of storage maintained for emergency standby during a disruption or outage. The policy limits the rationing during dry years to the 39 percent reduction in demand actually experienced by the average customer during the 1977 drought. (It should be noted that in 1988 this percentage would be 35 percent to equal the hardship experienced by customers in 1977.) It assumed that customers would voluntarily reduce their water use by 25 percent in the six months prior to the year of rationing. The District maintains a minimum of 120 days of standby storage for short-term supply outages which is discussed in detail in Chapter II. The full text of the District's policy is shown in Figure III-20.

POLICY ON SALE OF SURPLUS WATER

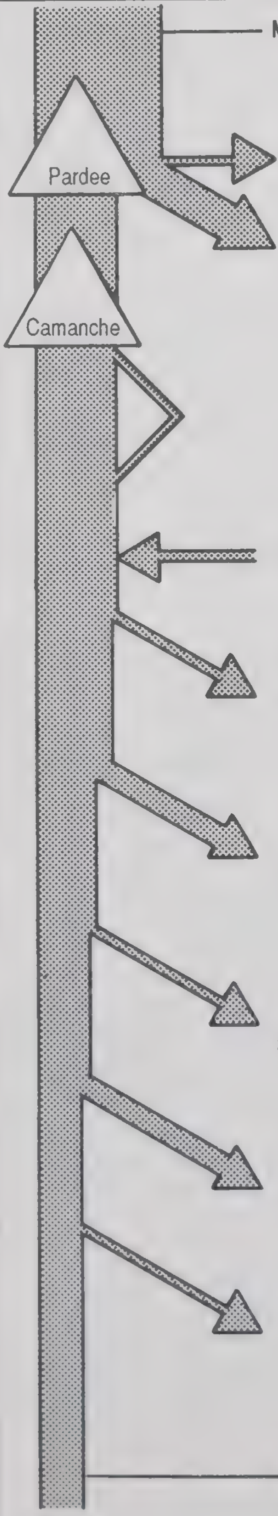
Over the years, EBMUD has received a number of requests to supply surplus Mokelumne River water to adjacent areas. As a result, in October 1986, the District adopted a policy on the Interruptible Sale of Surplus Water.

EBMUD will consider requests for water supplies outside the ultimate boundary on an individual basis in accordance with established policies and

Mokelumne River Flow Downstream of Pardee

(Acre-Feet per Year)

Figure III-19



	WATER YEAR 1979 (typical)	AVERAGE	RANGE	MAXIMUM ENTITLEMENT
Mokelumne Hill Gage	678,300	735,500	150,300—1,788,090	——
Jackson Valley Industrial District	3,000	1,500	0—3,800	5,000
EBMUD Aqueduct Draft	187,100 (= 167 MGD)	196,500 (175 MGD) (20 years)	130,600—245,700 (117 MGD—219 MGD) (Last 20 years)	364,000 (= 325 MGD)
Fish Hatchery Releases	16,200	18,300	5,900—23,300	13,000
Intermediate Inflow	7,100	6,600	80—13,900	——
North San Joaquin Water Conservation District*	7,400	7,400 (without 1976 and 1977)	4,600—9,500 (0 in 1976 & 77)	20,000
Woodbridge Irrigation District*	76,200	95,100	51,400—121,700	116,700 (= 60,000 Permanent Regulated + 56,700 Interim)
Riparians and Senior Appropriators*	14,600	13,700	10,100—18,200	20,618
Channel Losses*	56,700	80,000	32,700—108,700	——
City of Lodi*	0	0	0	3,600 (If triggered by Lodi Decree)
Woodbridge Gage	341,700	453,800	15,800—1,559,600	——

*Also provides instream flows for fish.

Policy on Water Supply Availability and Deficiency

Figure III-20

IT IS THE POLICY OF THE EAST BAY MUNICIPAL UTILITY DISTRICT TO:

A. Evaluate the availability of the District's water supplies (supplies of the same or similar quality to that of the Mokelumne River supply) and determine the acceptable maximum level of average annual demand for the District's service area based on limiting the water supply deficiency in a repeat of 1976-77 hydrologic conditions to the percentage reduction in demand actually experienced by the average customer during the period of water rationing in 1977.

B. Review and report on the current and long-term adequacy of the District's water supplies annually on or about April 15. The report shall include the acceptable maximum level of demand, projected water requirements, and the estimated surplus in supplies over and above the projected requirements.

C. Make projections of average annual demand for evaluating the adequacy of water supplies assuming:

- Water service will be provided in response to reasonable requests for service to properties located within the District's service area.
- Annexation of property within the District's ultimate boundary will be considered pursuant to normal District procedures in response to reasonable requests for service.
- A water conservation program will be implemented as provided in the District's Urban Water Management Plan.

D. Review and report on the long-term adequacy of the District's water supplies when considering case-by-case decisions on requests for replacement supplies which would increase the average annual demand by one percent or more; or, annexation beyond the ultimate boundary.

- A request for annexation beyond the ultimate boundary for extension of water service to new development will be considered only if it represents the most practical and feasible method of obtaining service and the acceptable maximum level of average annual demand is not exceeded.
- A request for a replacement supply for another water agency will be considered only if the other agency maintains a reliable alternative source of supply. This requirement may be waived at the discretion of the Board of Directors when the replacement supply is needed because of serious water quality problems or for public health reasons.
- District Policy on Effects of Extension of Water Beyond the Ultimate Boundary shall be applicable in each case.

E. Consider appropriate demand management measures and/or implementation of a supplemental supply if existing supplies are found to be inadequate. In the event that demand management measures and the availability of supplemental supplies fail to result in a supply adequate to meet projected demand, equitably allocate the limited amount of excess supply in consultation with affected cities and counties.

Reference: Board Resolution 31,246, May 14, 1985

procedures. The estimated quantity of surplus water will be determined each year prior to May 1 in accordance with the provisions of the Policy on Water Supply Availability and Deficiency. Priority will be given to purchasers whose existing supply does not meet primary drinking water standards, and the charge for water will be based on the costs of operation and maintenance of the Mokelumne system plus a capital cost component. The full text of the District's policy is shown in Figure III-21.

The City of Brentwood is currently receiving supplies of surplus Mokelumne water (1.25 MGD maximum) to alleviate water quality problems and has requested a new agreement for 2.5 MGD. Contra Costa Water District has also requested 50 MGD of EBMUD surplus water for the same reason, and the District serves four additional customers whose combined use is less than 0.5 MGD of surplus water.

Supply Disruption

The risk of a supply outage due to an aqueduct failure in the Delta has been discussed in Chapter II. The required time to bring the aqueducts back into service could be 17 months or more, as suggested in earlier studies which show 33 months. The risk of a supply disruption is more critical than a drought. In a

Policy on Interruptible Sale of Surplus Water

Figure III-21

IT IS THE POLICY OF THE EAST BAY MUNICIPAL UTILITY DISTRICT TO:

Respond to requests from governmental entities for delivery of water by entering into contracts for the sale of surplus water on an interruptible basis.

Interruptibility. The sale of surplus water, as governed by Section 12804 of the Municipal Utility District Act, is by definition interruptible. Provisions of this policy designed to further assure interruptibility of delivery include the procedure by which purchasers must request delivery quantities each year for the District's determination of availability, the requirement that each purchaser maintain an adequate backup supply, and the provision for cancellation of the contract by either party.

Water Availability. The estimated quantity of surplus water will be determined each year prior to May 1, in accordance with the provisions of the Water Availability and Deficiency Policy. The sale of surplus water must have no adverse impact on the availability of water to customers within the District. The District reaffirms that its first obligation is to serve customers within the District.

Quantity To Be Sold. The total quantity to be sold each year will be limited to the quantity of surplus water estimated to be available. Each purchaser shall pay for a minimum quantity of not less than 20 percent of the maximum annual quantity to be delivered under its contract, provided that the minimum quantity is available. Annual requests for delivery quantities shall be submitted to the District by April 1 each year. If the total of all requested deliveries exceeds the water estimated to be available, the allocation to each purchaser will be proportionate to the average of the actual quantities of surplus water used in the preceding three years or the average of the minimum quantities paid for in the same period, whichever is greater, subject first to the priority given below. If water is unavailable to a purchaser in any year, then EBMUD shall have no obligation to deliver water under that contract for that year (May 1 to April 30).

Priority. In the allocation of the available quantity of surplus water each year for delivery under existing contracts or new contracts, the first priority shall be given to the requirements of purchasers whose existing supply does not meet primary drinking water standards.

Backup Supply. Each purchaser shall maintain a backup supply adequate to meet the demand in its service area when the delivery of surplus water is reduced or interrupted.

Costs. The charge for water will be based on the costs of operation and maintenance of the Mokelumne system including the costs of pumping and lost power revenues, plus a capital cost component equal to a proportionate share of the District's original cost of constructing the existing facilities. Purchasers shall pay the one-time cost of installing the connecting facilities and any subsequent costs of repair or removal.

Cancellation. A contract may be cancelled by either party on July 1 of any year provided that a minimum of 45 days' advance written notice is given.

Water Conservation. Each purchaser shall provide by April 1 of each year an updated report on water management in its service area to assure that the purchaser's water conservation efforts will achieve improvements in the efficiency of water use similar to those adopted by the District.

Supplemental Water Supply. Each purchaser shall cooperate with and assist the District in obtaining increased quantities of water equivalent in quality to that being delivered from the Mokelumne River, including but not limited to administrative, legislative, and planning activities.

Reference: Policy 53/Board Resolution 31,735, October 7, 1986

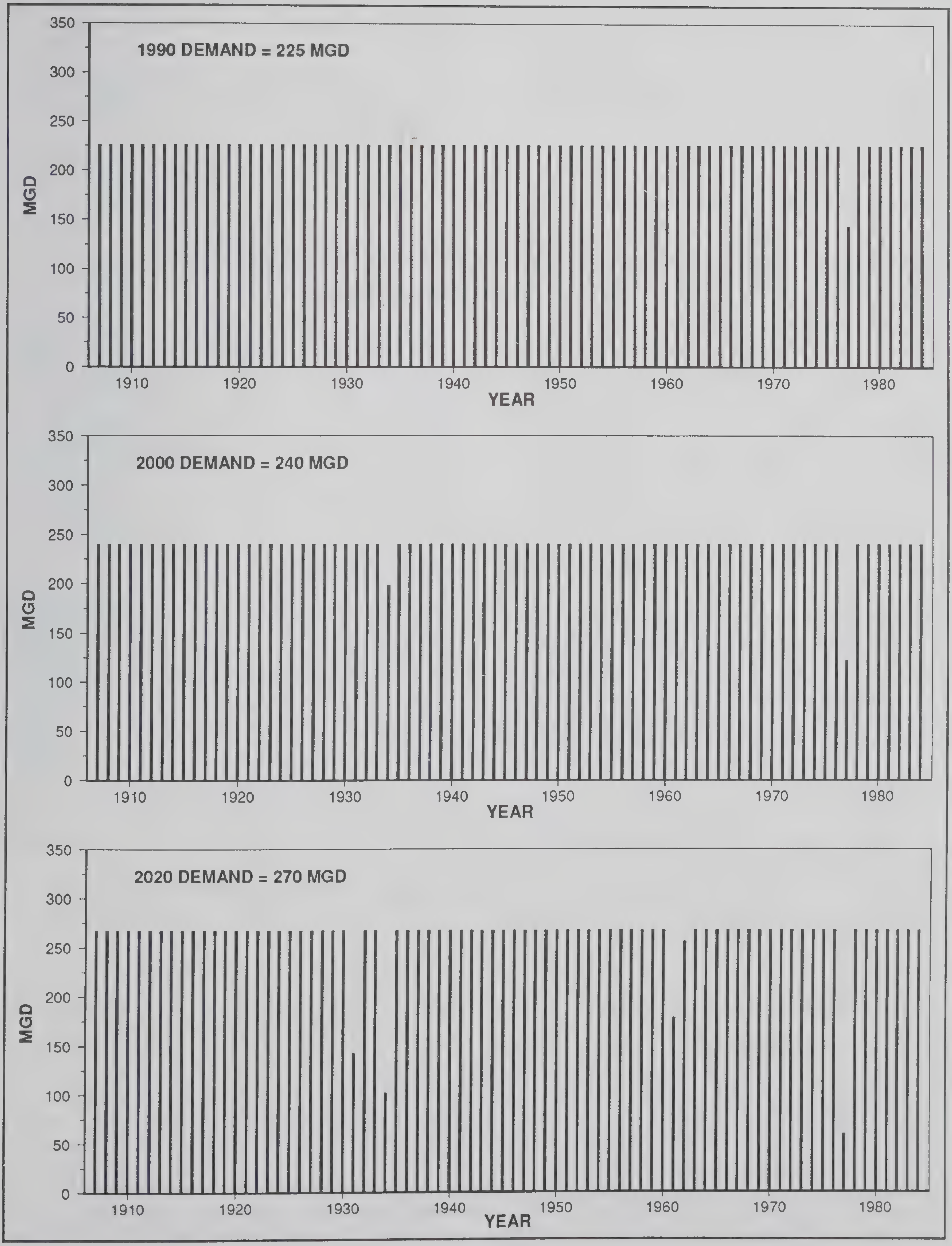
drought, the availability of the Mokelumne supply is reduced — in an outage, the supply is not available. It is true, particularly as Delta islands become progressively unstable, that emergency supplies from the Delta may be unusable due to sea water intrusion resulting from several levee failures.

Recent Experience Changes Availability

The need to make greater reductions in dry years as demand increases is illustrated in Figure III-22. Minimizing such reductions by keeping demands as low as possible could be difficult. For instance, EBMUD's effort in 1987 to have customers voluntarily reduce demand by 12 percent during the last half of the year did not achieve that result, although it may have kept demand from increasing more. Obviously, the intended results of a water conservation program are not always reliable and predictable. Public acceptance of the need to conserve and the conservation measures are important factors.

Mokelumne Supply Availability

Figure III-22



As explained in the security discussion, EBMUD experience and studies show that water pricing is not effective as a means of reducing normal year demand. On the other hand, the 1977 experience with water rationing showed that the threat of severe financial penalties for excessive use coupled with the declaration of an emergency can be effective on a short-term basis.

Drought Limitations

District water users, particularly industrial customers, cannot reduce water use as much as they did in 1977. The level of hardship experienced by large and small landscape irrigators during the 1976/77 drought resulted in customer losses of about $115 million in 1988 dollars. To reduce the level of hardship and user costs, drought restrictions should be reduced. In addition, industrial and institutional customers became more efficient in their water use by installing new equipment and devices, repairing leaks, and modifying processes. This increased efficiency, together with more efficient plumbing fixtures in new construction and increased use of low water use landscaping, means that a rationing program today to achieve a 39 percent reduction will cause a much greater hardship than it did in 1977. As water conservation efforts continue to improve water use efficiency, the same reduction will become even more difficult. Figure III-23 indicates that demand reductions in 1988 would be only 35 percent.

As further water conservation and reclamation measures are implemented, water use efficiency will continue to increase. Therefore, the planned maximum reductions for the various categories of customers should be reduced.

In light of this and also to reduce the severity of rationing to a more reasonable level, the planned maximum reductions for the various categories of customers could be reduced as shown in Figure III-23 with an overall maximum reduction of 25 percent. Figure III-24 shows the effect on availability of the Mokelumne supply if the limit on rationing is reduced from 39 to 25 percent.

PROJECTED WATER USE

Service Obligation

State law requires EBMUD to provide water service under reasonable conditions to all customers located within its service area and annexed territory within its ultimate boundary if it is reasonably feasible to do so. EBMUD has tried to anticipate the needs of its customers and assure that the water supply system is adequate, that service is reasonable, and that development and redevelopment which is served meets the planning requirements of all cities and counties.

Water Demand Projections

Water demand projections are based on customers' water use patterns and projected data from various sources such as the Association of Bay Area Governments (ABAG), the California Department of Finance, and planning agencies in each city and county in the EBMUD service area.

Projections of residential water use are based on housing and population projections and data on residential water use patterns. Figure III-25 shows the

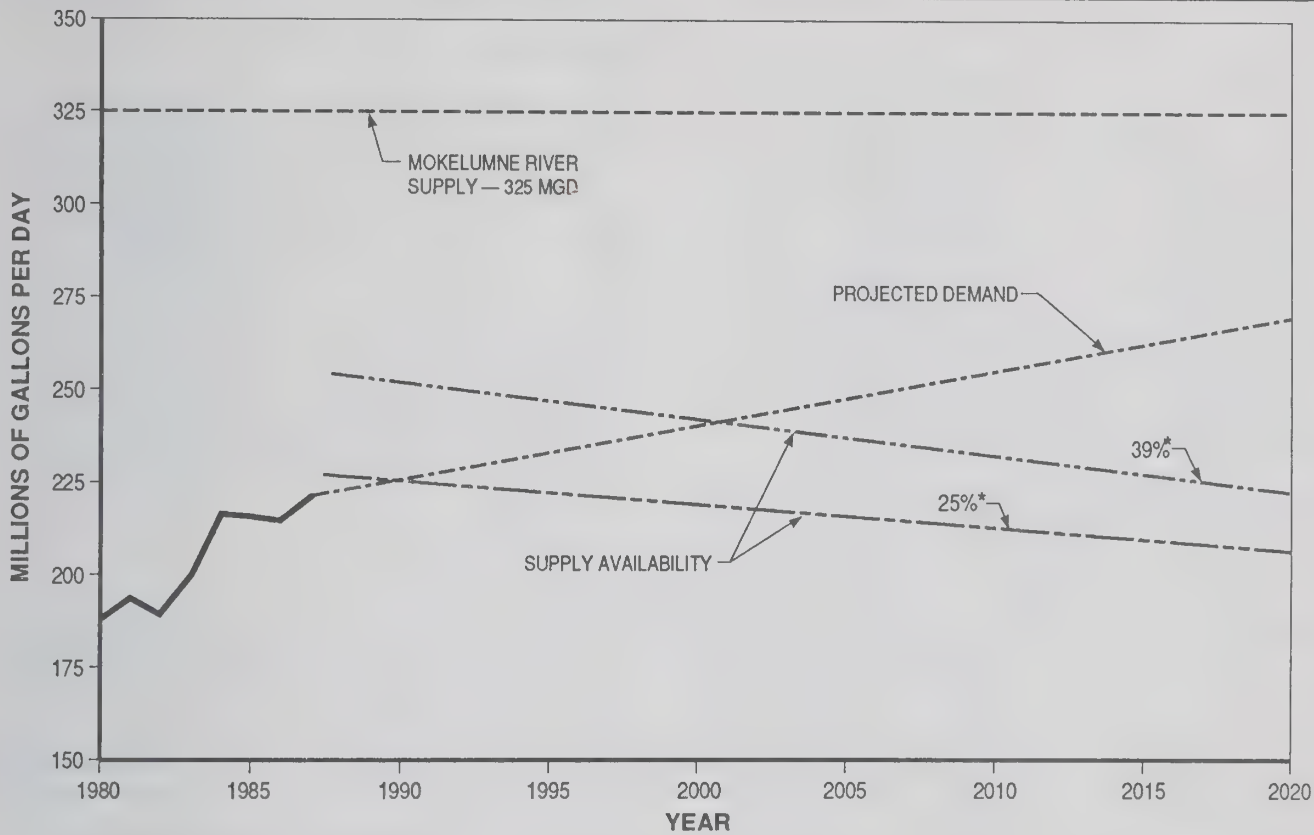
Demand Reduction in Drought

Figure III-23

CUSTOMER CATEGORY	ACTUAL DEMAND REDUCTION IN 1977	ACHIEVABLE REDUCTION IN 1988	ACHIEVABLE REDUCTION IN 2020	REDUCED SEVERITY IN DROUGHT
Residential				
— Single family	49%	44%	42%	35%
— Multi-family	23%	23%	20%	15%
Commercial and Institutional	39%	34%	28%	25%
Industrial				
— Petroleum	18%	12%	0%	0%
— Other	29%	9%	5%	5%
Parks, Golf and Cemeteries	55%	47%	35%	30%
OVERALL	39%	35%	31%	25%

Supply Availability

Figure III-24



*Limit on rationing in second year of drought like 1976-77.

projected population trend in the EBMUD service area. Figure III-26 shows the projected housing requirements in the EBMUD service area. Increase in housing is projected to occur throughout the EBMUD service area with most of the increase (about 60 percent) occurring in the western region.

Future water demands within the present EBMUD service area and ultimate boundary have been calculated for the period 1986 through 2020 and are shown in Figure III-27. Figure III-28 shows water use for new housing units.

The planning level of projected water use between 1986 and 2020 is taken as the mean of the high and low projections plus one standard deviation of 10 MGD to reflect uncertainty due to the short-term fluctuations discussed above.

Water requirements are the projected water demand less the savings that result from water conservation and water reclamation programs already in place or underway. The present and additional water conservation program is expected to reduce water demand by about 3 percent (about 7 MGD) by the year 2020. Water reclamation projects are expected to save an additional 5 MGD by the year 2020. The water conservation and water reclamation programs are described in the alternatives section of this chapter. The expected water savings from a fully effective water conservation and water reclamation program is about 12 MGD (5 percent) by the year 2020.

In the year 2020, the demand is expected to be in the range of 270 MGD to 280 MGD depending on the effectiveness of the water conservation program. The planning level of demand assumes that the current water conservation measures will be implemented successfully and achieve the estimated water savings. Therefore, the planning level of demand is 270 MGD in 2020.

Existing Terminal Storage Limitations

A fixed amount of storage space is available for standby in the existing terminal reservoirs. As demand increases, the storage required to maintain 120 days of supply through a drought also increases. Consequently, the storage available for use during the drought decreases. Sometime between 1995 and 2005 additional terminal storage or additional supplies are

needed to ensure that customers do not have to reduce demand during a drought by more than 25 percent.

When demand exceeds 252 MGD, the storage required to maintain the 120 days of supply will exceed the total standby storage space available in the existing terminal reservoirs. Figure III-29 illustrates that, at this point, additional terminal storage will be required to maintain the 120-day standby supply without sacrificing storage allocated to regulation. Both the regulation storage and the 120-day standby storage requirements are independent of the source of supply. Therefore, storage for these uses is needed with the Mokelumne River supply and regardless of implementation of any new supplies.

Areas Served by EBMUD — Figure III-25

CITY/COMMUNITY	1985 POPULATION[1]	2000 POPULATION
Alameda County		
Alameda[2]	70,400	73,700
Albany[2]	15,100	15,100
Berkeley[2]	106,600	103,300
Castro Valley[3]	45,500	50,500
Emeryville[2]	5,000	6,600
Hayward[4,5]	14,900	19,500
Oakland[2]	352,100	361,500
Piedmont[2]	10,400	10,200
San Leandro[4]	82,100	89,900
San Lorenzo[3]	20,500	20,000
Subtotal	722,600	750,200
Contra Costa County		
Alamo-Blackhawk[3]	13,200	
Danville[4]	32,100	17,500
El Cerrito[4]	29,000	27,500
Hercules[4]	9,700	18,400
Lafayette[4]	22,600	22,100
Moraga[4]	15,000	16,600
Orinda[4]	17,300	16,600
Pinole[4]	24,600	25,600
Pleasant Hill[4,5]	5,400	5,800
Richmond[4]	90,700	101,200
Rodeo-Crockett[3]	11,300	12,000
San Pablo[4]	24,900	24,700
San Ramon[4]	25,500	38,900
Walnut Creek[2,5]	42,100	44,300
Subtotal	363,400	412,800
TOTAL	1,086,000	1,163,000

[1] 1985 estimate based on ABAG projections
[2] City
[3] ABAG Subregional Study Area
[4] City Sphere of Influence
[5] City not entirely served by EBMUD; population shown is served by EBMUD. For these cities, year 2000 projection assumes portion served by EBMUD grows at same rate as entire city.

PROJECT ALTERNATIVES TO MEET SUPPLY NEEDS

Do Nothing

To do nothing would mean a continuation of the problem of water shortages with an increasing severity of rationing as demand increases in the future. When demand exceeds about 240 MGD around the year 2000, the necessary percentage reduction in demand will be greater than the 39 percent achieved in 1977.

Delta water may also have to be used. Chapter IV discusses in detail EBMUD's experience with Delta water during the 1976-77 drought. Because Delta water quality would be even lower during droughts, the potential health risks of using Delta water must be considered.

Water Conservation Alternative

This section summarizes the District's current water conservation activities and establishes the "Base Case" for water conservation already in effect at EBMUD. An alternative conservation program consisting of the base program plus additional measures is also presented. The additional measures proposed are those found to be most reasonable, feasible, and publicly acceptable. Other measures which have been considered are identified in Appendix A.

An earlier section provided background information on the development of water conservation efforts at EBMUD. The Base Case program contained in this section describes the current status of ongoing measures with projections of future costs and water savings for each measure.

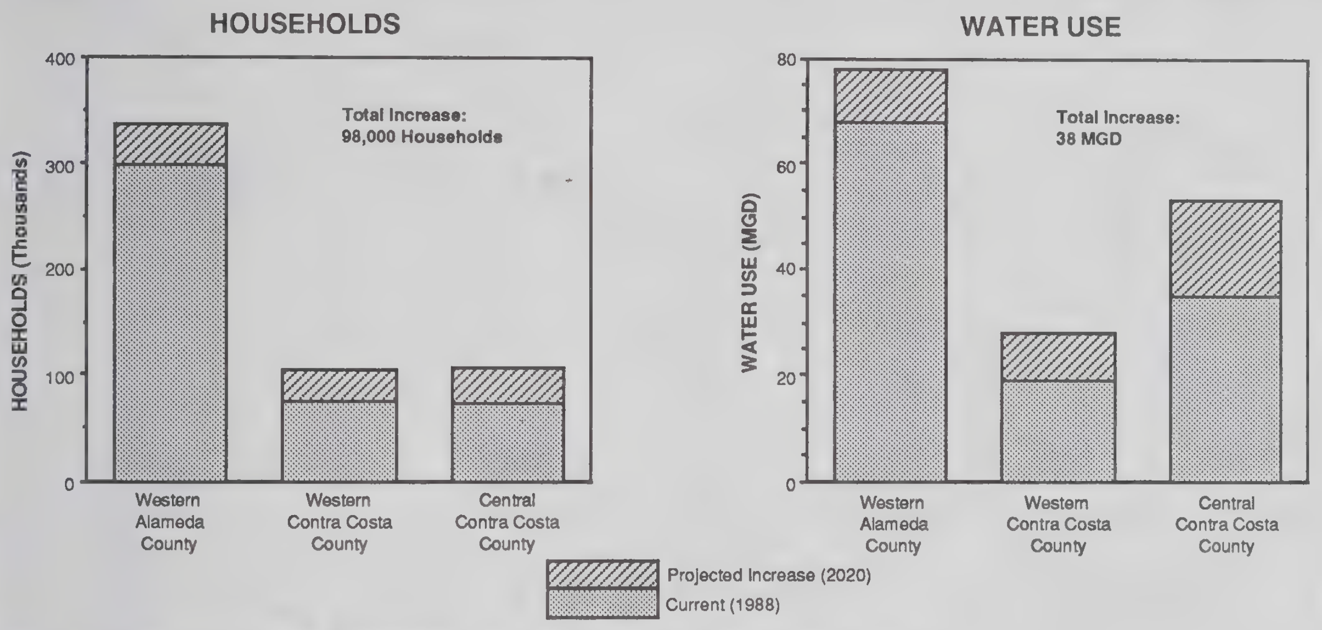
BASE CASE

Figure III-30 describes the estimated expenditures and savings for current water conservation measures including continued education programs, programs to advise customers, and audits for residential and commercial customers. The Base Case also includes provisions for increased technical guidance in the design and construction of landscaped areas. It is assumed that all new construction will comply with State water conservation regulations, but that the technology to be employed in saving water will be that which exists today.

Water savings shown in Figure III-30 are projected to occur as a result of continuing conservation activities at current levels through the year 2020. The savings indicated build up gradually over time and are not expected to be fully realized until 2020. Also, actual savings may differ from that projected. As the District gains more experience with these measures and is able

Projected Increases 1988 — 2020

Figure III-26



Source: Association of Bay Area Governments, State Dept. of Finance, EBMUD Office of Planning

Water Demand and Requirements Projections (MGD)

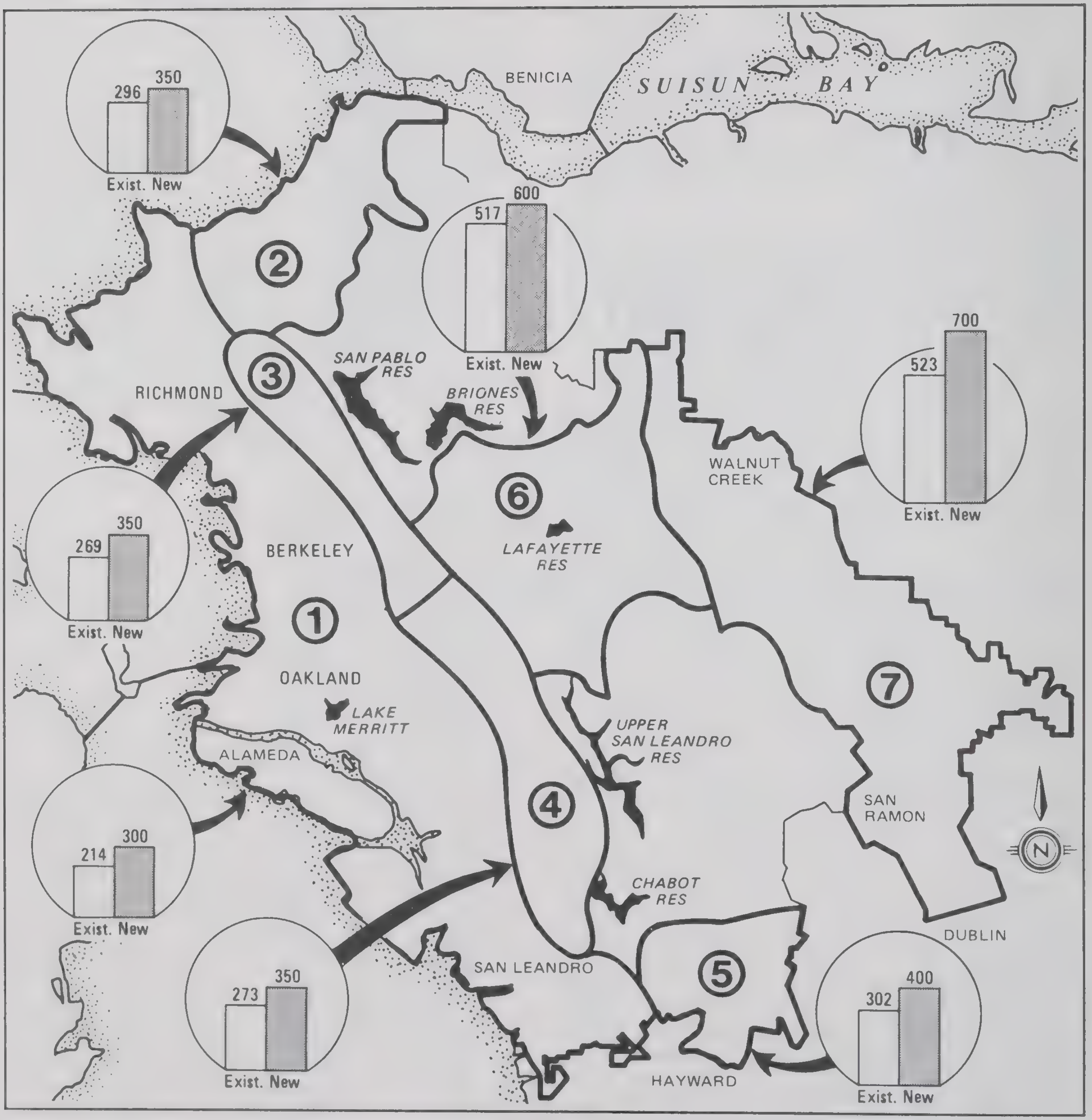
Figure III-27

CATEGORY	1986	1990		2020	
		LOW	HIGH	LOW	HIGH
Customer Use (Metered)					
Residential — Single Family	91	87	99	114	129
— Multi-Family	31	30	31	32	37
Commercial & Institutional	32	26	30	32	41
Industrial — Oil Refineries	15	18	21	16	23
— Other	15	14	15	17	23
Park, Golf, and Cemetery	12	9	10	11	13
Miscellaneous	2	2	2	2	3
Subtotal*	198	185	207	224	268
District Use	1	1	1	1	2
Unaccounted-for-water**	16	16	18	20	24
Total Demand*	215	203	227	247	294
Planning Projection					
Average of Demand Range		215		270	
Variance for weather and other conditions		+10		+10	
Projected Additional Savings					
— Water Conservation		-0.3		-4	
— Water Reclamation		-0.2		-5	
WATER REQUIREMENT*		225*		270*	

*Totals may not equal sum of categories due to rounding.
**Difference between measured water delivered into the distribution system at the filter plants and the total of all customer billed quantities.

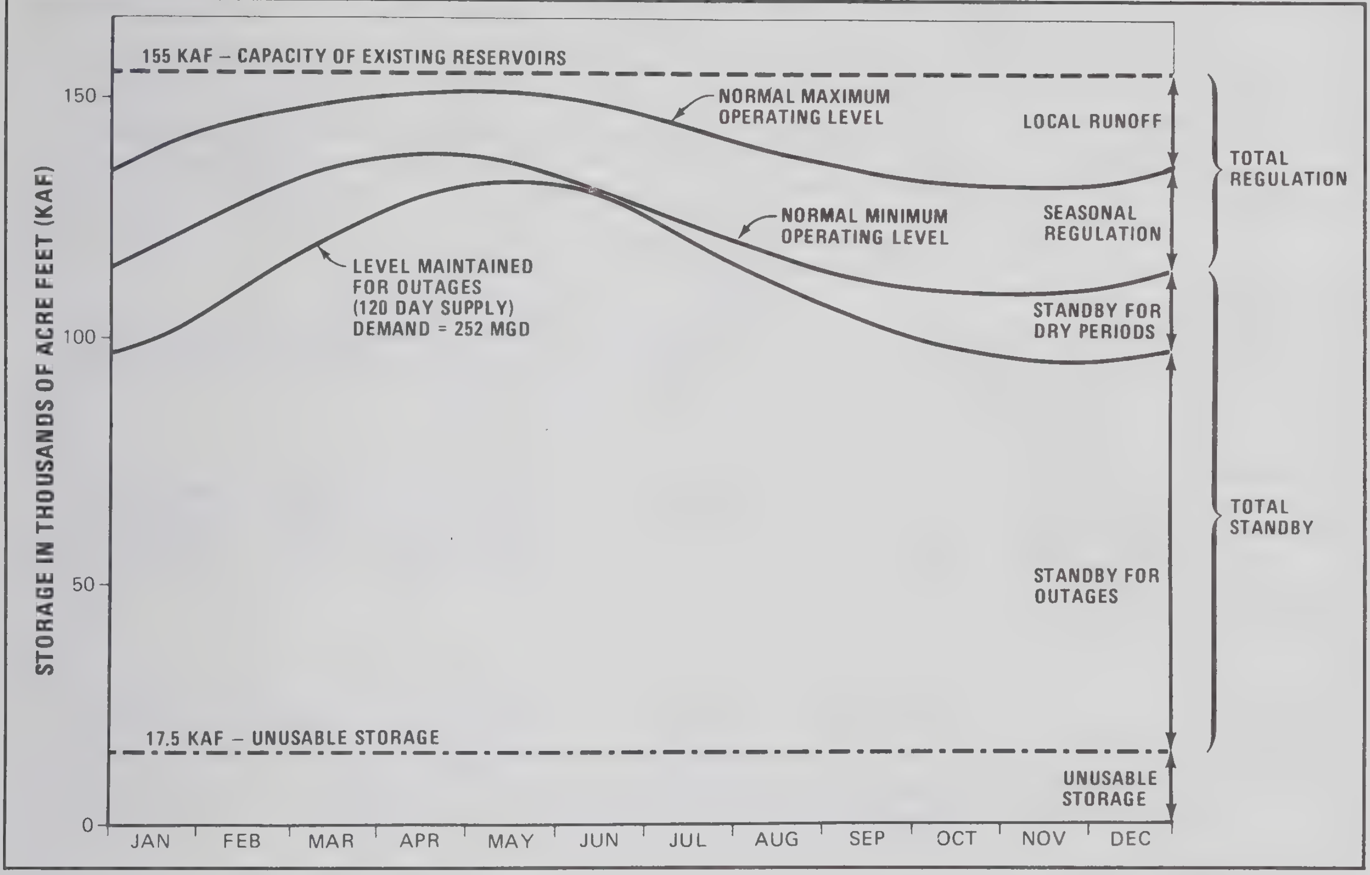
Single Family Residential Water Use by Region for Existing and New Customers (Gallons per Day per Household)

Figure III-28



Limitations of Terminal Reservoirs at 252 MGD Demand

Figure III-29



to collect data on water saved, the projected water savings and the measures themselves may change.

Metering. The EBMUD distribution system is 100 percent metered. Studies have indicated that metering results in an average water use reduction of 20 percent as compared to unmetered use. However, since the water use effect of metering is already included in the District's water use characteristics, no additional water savings are attributed to metering.

The District spends $400,000 annually purchasing and installing meters for new customers and $1,300,000 for inspecting, testing, and repairing existing meters to assure water use is measured accurately and revenues are collected fairly.

Public Information and School Education. Water conservation public information and education material available from the District is described earlier in this chapter. The information is intended to increase public awareness of the water use efficiency and inform customers of opportunities to save water.

The cost of this effort varies from year to year as new material is produced; however, the average annual cost of the District's public information campaign on water conservation is estimated to be $75,000 per year. No water savings are attributed to this effort although some water savings may result.

In summary, the Base Case conservation program should result in an additional water savings, above that already present in customer water use characteristics, of approximately 4.0 MGD by the year 2020. It should be noted that these savings are conjectural since it is impossible to measure the actual savings resulting from many of the measures. The total annual cost of the District's current water conservation program and leak detection program is estimated to be $6.7 million per year. This does not include the cost of the leak detection, pipeline rehabilitation, and metering efforts since these functions would be performed regardless of their water saving benefits.

Leak Detection and Pipeline Rehabilitation. The District's leak detection and pipeline rehabilitation program is described in detail earlier in this chapter. Water saved as a result of the leak detection program ranges from 0.5 MGD to 1.5 MGD each year. The water saved is not cumulative since the leaks would be discovered within a year or two even without the leak detection program. Early detection and repair

Water Conservation Base Case

MEASURE	TYPE OF USE AFFECTED	BENEFITS OF MEASURE
LEAK DETECTION AND PIPELINE REHABILITATION • Leak detection crews survey approximately 300 miles per year • Repair 600-800 leaks and breaks per year • Replace approximately 7.5 miles of pipe per year due to poor condition	Distribution System Losses	• Milnimize system losses (unaccounted-for water) • Maintain integrity of distribution system
WATER METERING • All customers metered • All District Facilities metered • Routine inspection, testing, and repairing of meters • Past and present water use shown on customer bills	All Water Use	• Equitable collection of revenues • Reduces overall water consumption • Provides means for identifying leaks on customer's side of meter • Reduces unaccounted-for losses due to inaccurate meter
WATER SAVING DEVICE DISTRIBUTION • Distribute free retrofit kits to customers • Kits include: low flow showerhead, toilet displacement bag, dye tablets • Approximately 20,000 kits distributed per year	Residential Inside Use	• Devices have potential to save up to 9.8 gpcd (or 23.0 gpd/SFDU and 17.6 gpd/MFDU in 2020) • Low flow showerhead also saves energy due to reduced hot water usage
WATER AUDITS • Program initiated in 1987 • 100 water audits performed • Anticipate 200 audits per year	MF Residential Commercial & Institutional Inside & Outside Use	• Recommend methods of improving water use efficiency • Identify opportunities to save water • Identify potential leaks
LANDSCAPE CONSULTATIONS • Program initiated in 1987 • Approximately 50 landscape consultations • Anticipate 100 consultations per year	Residential Outside Use	• Recommend plants and materials for reducing outside water use • Review landscape plans and provide advice
LANDSCAPE WATER USE EFFICIENCY IN NEW DEVELOPMENTS • EBMUD established model guidelines for cities and counties to adopt • Contra Costa County and cities of Albany, Danville, El Cerrito, Piedmont and San Leandro have adopted modified guidelines • Guidelines have been imposed on three annexations to the District	New Developments Outside Use	• Requires new developments to conform to specified guidelines for landscaped area • Reduce outside water use by estimated 25%
DEMONSTRATION GARDENS • Construct approximately two demonstration gardens per year in cooperation with other agencies	Outside Use	• Demonstrate the attractiveness, low maintenance and low water use of drought tolerant landscaping
IRRIGATION UPGRADE PILOT STUDY • To be initiated in 1988 in cooperation with other agencies • Conduct studies to determine: - irrigation efficiencies - potential benefits of upgrading irrigation systems - potential effectiveness of an incentive/rebate program	Non-Residential Outside Use	• Develop data on potential water savings and cost effectiveness of upgrading irrigation systems • Determine customer responsiveness to incentives or rebates to encourage water savings
PUBLIC INFORMATION AND SCHOOL EDUCATION • Landscape Book and Brochure • Landscape Video • Exhibits • Speakers Bureau • Educational Software • Water Conservation Activity Center	All Water Use	• Provide information on efficient water use • Inform customers of conservation assistance available through other programs

Figure III-30

	COSTS OF MEASURE	ESTIMATED ADDITIONAL WATER SAVINGS IN 2020	CUSTOMER/COMMUNITY RESPONSE	COMMENTS
	• Leak detection - $600,000 per year • Pipeline repairs - $1,700,000 per year • Pipeline replacements - $4,100,000 per year	• NO ADDITIONAL WATER SAVINGS • Approximately 0.5 to 1.5 MGD saved each year; this savings is not cumulative • Continuation of program will maintain a low rate of unaccounted-for water losses	• Customer reported leaks are repaired promptly • District notifies customers of customer side leaks	• Continuous effort required to maintain long term integrity of distribution system
	• $400,000 spent per year on new water meters • $1,300,000 spent per year on inspecting and repairing meters	• NO ADDITIONAL WATER SAVINGS • Actual quantity of water saved is unknown • Nation-wide studies indicate 20% water savings when water is metered	• No adverse customer response to metering • Assists customer in locating leaks	• Standard District practice since 1923
	• No cost to customers • Kits cost District $3.00 each, or approximately $60,000 per year • Total program cost is approximately $72,000 per year	• PROJECTED SAVINGS: 1.9 MGD • Water savings from kits already distributed is unknown	• Customer satisfaction with kits is unknown • Actual installation rate and life of kits is unknown	• Requires continuous effort by District to maintain level of usage • Water saving potential significantly reduced when installed in homes built after 1978
	• District cost of program estimated to be $40,000 per year, primarily staff time • Modifications made by customers may have some cost; this is assumed to be offset by cost savings	• PROJECTED SAVINGS: 0.9 MGD • Savings from program to date is unknown	• Customer response to District recommendations is unknown	• District is monitoring the response to the program; no conclusions can be drawn at this time
	• Estimated total cost to District is $17,000 per year • High customer costs due to relandscaping; assume decision to relandscape and decision to use low water using materials is separate decision	• PROJECTED SAVINGS: 0.1 MGD • Water savings from program is uncertain	• Customer response to program is unknown	• District is monitoring the response to the program; no conclusions can be drawn at this time
	• Unknown administrative costs to be borne by cities and counties adopting guidelines • District cost estimated to be $30,000 per year	• PROJECTED SAVINGS: 1.1 MGD • Actual water savings is unknown; guidelines have just been implemented	• Guidelines not in effect long enough to determine response	• Other cities are considering guidelines and may adopt them in the future
	• Construction of two gardens per year estimated to cost $25,000 per year • Sponsoring agencies would be responsible for operation and maintenance of gardens	• NO ADDITIONAL WATER SAVINGS • Gardens are for demonstration purposes; no water savings are attributed • Gardens have demonstrated a potential for 90% water savings in outside use	• Public agencies are supportive of gardens	
	• Estimated cost to administer a pilot program is $5,000 • Assumes DWR would contribute the cost of upgrading an existing landscaped area • Cost to fully automate a large irrigation system ranges from $1,500 to $25,000/acre	• NO ADDITIONAL WATER SAVINGS • No water savings are attributed to the pilot program	• Customer response to incentive/rebate programs not known	
	• Total District cost is estimated to be $75,000 per year	• NO ADDITIONAL WATER SAVINGS • Water savings from public information is not quantifiable	• The District has received positive response from past public information and education efforts	• Public information and education is a necessary element of any balanced conservation program

helps the District minimize unaccounted-for losses and maintain a tight water system.

The total direct cost of the leak detection and pipeline rehabilitation program is estimated to be:

Leak Detection Program	$ 600,000/yr.
Repair of Pipeline Leaks and Breaks	1,700,000
Pipeline Replacement	4,100,000
Total	$6,400,000/yr.

Demonstration Gardens. The purpose of the District's demonstration gardens program is to show the public the attractiveness, low maintenance, and low water use of this type of landscaping.

Low water use landscapes have been demonstrated to reduce irrigation water use by up to 90 percent. However, no water savings for this measure are given since the purpose of the program is public awareness.

Water Saving Device Distribution. The District currently plans to distribute about 20,000 retrofit kits per year. The kits will include a low-flow showerhead, two toilet displacement bags, and dye tablets for finding toilet leaks. Approximately one-third of the kits will be distributed door-to-door in selected areas, with the remaining being available at District business offices. The primary focus of the device distribution will be single and multi-family residential customers.

Continuation of this program is estimated to save 1.9 MGD in 2020 based on the assumptions discussed above. Currently, the District is evaluating the rate of use and satisfaction with retrofit devices distributed to customers in the last year. Results of this evaluation may change some of the above assumptions.

Installation of low-flow showerheads may also result in energy savings for customers due to reduced hot water heating. This savings is estimated to be $24.80/year and $19.00/year for single and multi-family residences, respectively.

Water Audits. The purpose of water audits is to examine water use practices, detect leaks, and make recommendations for improved efficiency. The District plans to conduct about 300 audits per year. Multi-family residential and commercial and institutional customers will be targeted for the audits because of their water use characteristics. Both inside and outside water use practices will be examined. The District will monitor the water use of customers following the audit to determine how much water is actually saved.

Because this program was just recently initiated, data are not available on how customers have responded to District recommendations or on what water savings have resulted from changing water use practices as a result of the audit. Therefore, projected water savings will not be certain until reliable data can be produced.

Landscape Consultations. In 1987, the District initiated a program offering low water using landscape advice and information to customers planning to either install new or alter existing landscaping. The primary focus of this program has been residential customers, including apartment complexes, home owner associations; condominiums, and single family residences.

Water savings for this program are very difficult to estimate since the customer attitude toward drought tolerant landscaping is unknown. The District plans to follow-up consultations by monitoring water use and conducting surveys with customers to determine customer attitudes and water savings. Even if the program should achieve only limited water savings, it is important in maintaining a public awareness of opportunities to save water through landscaping techniques.

Landscape Water Use Efficiency in New Developments. The District's "model" guidelines establishing criteria for landscapes in new developments are intended to increase outside water use efficiency by 25 percent in new developments in the service area.

Water savings estimates for this program assume that guidelines will be imposed on all new developments (except single family residences) and that outside water use in these new developments will be 25 percent more efficient. This results in projected water savings in 2020 of 1.1 MGD.

Irrigation Upgrade Pilot Study. In 1988, the District plans to conduct an irrigation upgrade pilot study, in cooperation with other public agencies, to determine irrigation efficiencies and analyze the potential benefits of an incentive or rebate program to encourage upgrading irrigation systems. The study will focus on the District's 100 largest irrigators, which comprise approximately 7.5 percent of outdoor use.

The cost of fully automating and controlling a large irrigation system ranges from $1,500 to $25,000 per acre depending on the condition of the existing system. Items which could be considered in an upgrade include: master irrigation controllers, moisture sensors, check valves, low volume sprinkler heads, precipitation and wind override devices, pressure reducing valves, and separate valving determined by plant needs.

There are no data currently available on how much water savings could be anticipated from irrigation system upgrades. The purpose of the pilot study is to determine whether irrigation upgrades are cost effective, estimate potential water savings, evaluate current water use practices of the District's 100 largest irrigators, and determine the feasibility of offering an incentive or rebate to customer for upgrading irrigation systems.

The District will conduct the pilot study in cooperation with the Department of Water Resources (DWR) and another local agency.

ADDITIONAL WATER CONSERVATION PROGRAM

In developing the Water Supply Management Program, the District has evaluated additional water conservation measures beyond those already being implemented. Because the District has water available in excess of its needs a majority of the time, the approach has been to select voluntary type measures that either have been shown to be successful or have potential for being successful.

While the methods and technology are available to reduce water use, a major problem is determining the most appropriate method for implementing water conservation measures. For example, the District's demonstration gardens have shown that outside water use can be trimmed by 90 percent. To achieve this savings, the customers must be willing to spend time and/or money to change their landscaping, know and understand the water needs of the plants, and actively control and monitor actual irrigation.

The District's role in promoting and encouraging water conservation, short of a critical situation such as a drought, has focused on educating customers, and providing information on and incentives to saving water. The District assists customers in achieving efficient use and allows customers to determine to what extent they will conserve.

Figure III-31 summarizes additional water conservation measures that have the potential for water savings and are considered reasonable, feasible, practical, and acceptable. In summary, the alternative water conservation program, which includes the Base Case plus the additional measures indicated in Figure III-29, is estimated to provide 7 MGD of water savings by 2020. The total annual cost of this alternative conservation program is estimated to be about $560,000 per year, an increase of $296,000 over the current Base Case program.

The following describes in further detail the proposed conservation measures listed in Figure III-31.

Additional Demonstration Gardens. Currently, EBMUD is working with other public agencies to develop about two new demonstration gardens each year (see discussion on past and present water conservation activities). The District could increase its effort in assisting other agencies to build low water using landscape gardens in public areas.

The increased cost for developing more demonstration gardens would depend, partially, on the willingness of other public agencies to support the gardens. The purpose of the gardens is to demonstrate the attractiveness and low water use of drought tolerant landscapes. Therefore, no water savings are attributed to the demonstration gardens.

Expansion of Water Saving Device Distribution. As previously discussed, EBMUD plans on distributing approximately 20,000 retrofit kits per year to single and multi-family residential customers. This program could be expanded to distribute 30,000 kits per year, and door-to-door distribution could be increased. Single and multi-family residential customers would continue to be the primary focus of the program.

Water savings projections for the year 2020 are based on the same assumptions described for the existing program. The expanded kit distribution is estimated to save a total of 2.8 MGD in 2020, an increase of 0.9 MGD. This estimate may be high since it does not account for unknown factors, such as longer showers or double flushing of toilets, which may result from use of the retrofit devices. Water savings may also decrease with time as the percentage of pre-1978 homes declines.

Customers installing low flow showerheads will realize secondary benefits from reduced energy costs associated with hot water heating. It is estimated that annual energy savings would be approximately $24.80/year and $19.00/year for single and multi-family residential households, respectively.

Water Audits of Industrial Processes. The District's water audit program could be expanded to include industrial customers. Emphasis would be to encourage owners to install low water use equipment for sanitary, cooling, and process use. The scope of the audit would include water, wastewater, and energy audits (as appropriate) to increase customer response. Customer cost for plant modifications would be determined on a case-by-case basis. However, it is reasonable to assume customers would be reluctant to

make changes unless a long-term net benefit could be demonstrated.

Landscape Consultations. To date, the District has provided landscape advice when specific customer inquiries have been made. The District could increase its landscape consultation efforts by actively advertising the service through mailings and personal contact. The landscape consultations could also be expanded to include commercial and institutional customers in addition to residential customers.

Landscape Rebate - Pilot Program. The concept of providing incentives, in terms of District rebates to existing users, must be tested to determine effectiveness. Considering the fact that the average new home in the District is in the $200,000 price range and that the average monthly water bill even in the higher water using areas may be in the range of only $20 a month, a rebate may have to be quite significant to induce modifications resulting in significant water savings.

As part of a pioneering effort to encourage low water landscaping, the District could implement a pilot program to test the effectiveness of offering rebates to customers who install low water landscapes that meet District criteria. The program would be targeted to customers who were already contemplating re-landscaping their yards.

The District could test the program over a 2 to 3 year period to determine the level of customer interest in a cash incentive. It may be that a higher incentive will be necessary to encourage customers to use low water using plants and materials as opposed to more traditional landscapes. The details of a pilot program need to be developed.

Because this would be a 2 to 3 year program to test public response to a rebate as a method of encouraging water efficient landscapes, no water savings are attributed to this measure.

Landscape Irrigation Management. The purpose of this measure is to increase irrigation efficiency through improved scheduling using existing irrigation systems. The irrigation system upgrade pilot program, described earlier in this section, will evaluate the potential for water savings by upgrading irrigation systems. This measure would target large irrigation water users that could benefit from more efficient management of irrigation in landscaped areas.

The District would make an effort to have irrigation on all large lawn areas, such as golf courses and parks, scheduled using real-time climate data. This would be accomplished by holding training classes for professional landscape maintenance personnel on how to schedule irrigation based on average evapotranspiration (ET) values, encouraging upgrades of irrigation systems, and offering free audits for larger lawn areas. The District would maintain its weather station, established in 1987, to provide real time ET data and would assist in developing cooperative pilot and research projects.

The major component of this measure would be to educate customers in how to use real time evapotranspiration data for managing their irrigation. Customers would incur minor costs to educate personnel. Other expenses may occur if irrigation systems are modified or improved. However, because this would be a voluntary measure, it is assumed that any customer costs would be negligible and would be recovered through water saving benefits.

The willingness of landscape maintenance personnel to incorporate more efficient techniques is not known. However, if 20 percent of the parks and golf courses and 10 percent of other commercial and institutional customers reduce outside water use by 25 percent through improved irrigation management, an estimated 0.7 MGD could be saved by 2020.

OTHER MEASURES CONSIDERED

The Water Supply Management Program includes implementable alternatives. EBMUD and other advocates of water conservation, through the Urban Water Management Plan and other activities, have studied most, if not all, conceivable water conservation measures. Many of these measures are either theoretical, difficult to quantify, or can be implemented only under unique limited circumstances. Theoretical measures that have been considered in the conservation analysis are summarized in Figure III-32 and described in more detail in Appendix A.

One measure considered would require all homeowners to replace existing toilets with ultra low flush (1.5 gal/flush) toilets at the time the property is sold. The potential water savings from this requirement may be significant; however, consideration must also be given to customers who are required to spend several hundred dollars to purchase and install new toilets. While this measure has just been implemented only in Monterey County, that area is experiencing a severe long-term water shortage and has different needs to be met.

Additional Water Conservation Measures

Figure III-31

MEASURE	TYPE OF USE AFFECTED	ESTIMATED BENEFITS OF MEASURE	ESTIMATED COSTS OF MEASURE	ESTIMATED ADDITIONAL WATER SAVINGS IN 2020	CUSTOMER/COMMUNITY RESPONSE	COMMENTS
EXPANSION OF WATER SAVING DEVICE DISTRIBUTION • Increase distribution of retrofit kits from 20,000 per year to 30,000 per year • Kits include: low-flow showerhead, toilet displacement bag, dye tablets •Iincrease door-to-door distribution of kits	Residential Inside Use	• Devices have potential to save up to 9.8 gpcd (or 23.0 gpd/SFDU and 17.6 gpd/MFDU in 2020 • Low flow showerhead also saves energy due to reduced hot water usage	• Customers would continue to receive kits free of charge • Retrofit kits cost the District $3.00 each for an increased cost of $30,000 per year for the kits • Total program costs estimated to be $117,000 per year, or an increase of $45,000 per year	• PROJECTED SAVINGS: 0.9 MGD • This is the incremental savings from expanding the program; total from device distribution would be 2.7 MGD	• Same as current program	• Same as current program
WATER AUDITS FOR INDUSTRIAL PROCESSES • Expand water audit program to include industrial processes • Anticipate 100 industrial audits per year • Emphasis would be on installing low water use equipment for sanitary, cooling and process water • Audits would include water, wastewater and energy (as appropriate)	Industrial Inside Use	• Industrial customers tend to use large quantities of water; therefore a relatively small number of audits could result in high water savings	• District costs for this program are estimated to be $75,000 per year, primarily staff time • Customers may be faced with costs to modify processes. However, these costs are assumed to be offset by cost savings	• PROJECTED SAVINGS: 1.1 MGD • Water savings resulting from industrial water audits would be estimated on an individual basis	• Industrial customers have demonstrated a willingness to reduce water use when overall cost savings can be achieved	• Long payback periods for process modifications may affect customer response
LANDSCAPE CONSULTATIONS • Expand current Landscape Consultation Program to non-residential customers • Anticipate 200 consultations per year • Landscape consultations would be similar to water audits but would focus on outside water use	Non-Residential Outside Use	• Target larger landscape areas where potential water savings would be greater • Provide information on plants and materials, irrigation systems, etc. • Review landscape plans and make recommendations	• District cost for this program is estimated to be $38,000 per year, or an increase of $21,000 per year over the current program • Customers would have landscaping costs, but these are assumed not to increase due to use of low water use plants and materials	• PROJECTED SAVINGS: 0.2 MGD • This is the incremental savings from expanding the program; total from landscape consultations would be 0.3 MGD	• Customer response to this program is unknown	
IRRIGATION MANAGEMENT • Encourage irrigation of large landscaped areas to be scheduled using evapotranspiration data • District would conduct training seminars for landscape maintenance personnel	Non-Residential Outside Use	• Increase irrigation efficiency without changing landscapes	• District costs estimated to be $5,000 per year to conduct training seminars • Customers would incur minor costs in training landscape maintenance personnel	• PROJECTED SAVINGS: 0.7 MGD	• Customer response to this program is unknown	• District maintains a weather station which can provide evapotranspiration data to landscape personnel
ADDITIONAL DEMONSTRATION GARDENS • Develop 4 (rather than 2) demonstration gardens in public areas each year • Work with local public agencies to encourage use of low water landscaping in public areas	Outside Use	• Demonstrate attractiveness and low maintenance of low water using landscapes	• Construction of four gardens per year estimated to cost an additional $25,000 per year • Sponsoring agencies would be responsible for operation and maintenance costs of gardens	• NO ADDITIONAL WATER SAVINGS • Gardens are for demonstration purposes; no water savings are attributed	• Public agencies have been supportive of gardens	
LANDSCAPE REBATE • Pilot program to encourage use of low water using landscapes by existing customers • Offer rebates for customers who meet District criteria	Existing Customers Outside Use	• Encourage customers to choose low water using plants when relandscaping • Reduce outside water use	• Pilot program would last for 2 to 3 years • District costs estimated to be $120,000 per year	• NO ADDITIONAL WATER SAVINGS • No water savings are attributed to the pilot program	• Pilot program would test public responsiveness to incentives to encourage low water landscapes	• Program assumes customers have already decided to modify existing landscapes

Theoretical Measures* Figure III-32

MEASURE	WATER SAVINGS (MGD)
Landscape Rebate	1.3
Advanced Plumbing Code	2.1
Mandatory Toilet Replacement for Residential Customers	12.8
Mandatory Toilet Replacement for Non-Residential Customers	0.5
Water Efficient Technology	0.7
Potential Additional Savings	17.4

*These measures may have the potential for additional water savings but they are costly, have unproven records and/or impose mandatory restrictions.

ASSESSMENT OF WATER CONSERVATION

This chapter addresses the goal of assuring the District has sufficient water supplies to meet the reasonable demands of its customers. The purpose of the District's conservation program has been to assure that customers' demands are reasonable and avoid waste.

In nine years out of ten, the District's water supplies are more than sufficient to meet customers' demands. However, climatic patterns in California occasionally result in dry periods in which the availability of supply may be insufficient to meet demands. This occurred during the 1976-77 drought and is occurring again in 1987-88. EBMUD recognizes that it is not reasonable, nor feasible, to assure that 100 percent of customers' water needs are met 100 percent of the time. When adopting its Water Supply Availability policy in 1985, the District established criteria in which, during infrequent dry periods, insufficient water supplies would be met by cutbacks in customer demand. With the policy, the District linked water availability to both long-term conservation and short-term demand reduction measures. One effect of a long-term conservation program is to reduce the District's ability to respond to a drought with short-term demand reduction measures.

It has been documented that customers will respond to water use reduction programs only in emergencies and in rare periods of water deficiency. This was illustrated in 1977. Since water supplies are more than adequate in most years and the cost factors associated with increasing those supplies are within the level of affordability, it would seem that the most reasonable approach would be to steadily improve water use efficiency as measures are demonstrated to be both acceptable and cost-effective and at the same time expect the District's water users to make drastic cuts during times of shortage. This approach has been advocated in current District planning.

KEY FACTORS

In reviewing results from the analysis of the base conservation program, the alternative program, and District response to the shortages of 1976-77 and 1986-87, the following key factors should be considered:

- Water conservation programs are not directly comparable to a new water storage reservoir or a connection to a new source of supply, since conservation programs take years to implement, have unproven and uncertain success, and are difficult to quantify.

- The measures that appear feasible have been included in the proposed conservation alternative, which could be implemented individually or in connection with other water supply alternatives described in this Chapter.

- It is unreasonable to assume that measures that have not been demonstrated in the EBMUD or on a large scale in other locations are currently feasible and assessable alternatives, i.e., the acceptance of requiring a 1.5-gallon-per-flush toilets is not readily determinable, particularly when retrofitted in individual homes, nor is it to determine what health authorities would require to allow the installation of a dual distribution system in apartments, hotels, or even individual houses.

- In assessing how much water might be saved by these measures, it is difficult to predict the quantity since accurate data, except on small scale demonstration projects for specific appliances like low-flow showerheads, are not available.

- There are social and economic impacts of various water conservation measures. For instance, many District residents of multi-family and single family homes, as well as users of institutions such as the University of California, enjoy the effects of large areas of greenery. These benefits, which are related to the way people view the urban landscape, are difficult to quantify. Clearly considerable water savings can be achieved without affecting these benefits, but measures, such as prohibition of lawns or other water-intensive landscaping, which some believe may substitute water conservation for major water

supply development, would have the effect of changing the appearance of the urban landscape.

- The availability of adequate supplies of fresh water is a key factor in maintaining a strong existing economy, as well as development and redevelopment of a region. The development and redevelopment of the East Bay depends upon an adequate water supply that is perceived to be adequate. If the District undertakes a significant series of water conservation measures that are more rigorous than those employed in the United States generally or in Northern or Southern California in particular, this area would be perceived as having a long-term water deficiency. It is unlikely that this would have a positive effect on the East Bay's economy.

- There appears to be a water rate effect of water supply shortage. Perhaps the most water-short area in the Bay Area has been Marin County. It is not coincidental that the Marin Municipal Water District's water rates are almost double the average of the Bay Area and significantly higher than EBMUD's rates. This appears to be due to an intentional policy to delay the construction of new water supply facilities and when such facilities are constructed to size them relatively small compared to the demand. Water rates to the average user are kept low by the construction of large facilities that ultimately have low unit costs. This approach has been the basis of the District's present economical rate structure.

This chapter has attempted to describe the District's existing water conservation programs, outline feasible improvements to that program as an alternative, and describe other measures which are not deemed to be feasible at this time, particularly those listed in Appendix A. Summarizing the status of water conservation and the conclusions of this chapter:

- EBMUD's total demand is about the same now as it was in 1975. Although the residential demand has increased, industrial demand has been sharply reduced.

- This increased efficiency means that the 1977 reduction level of 39 percent could not be achieved without significantly greater hardship and that if the shortage were to occur today, the same hardship would occur at the 35 percent level of savings and this level is likely to reduce to 31 percent by the year 2020.

- In addition to programs currently underway, the alternative water conservation program could succeed in achieving additional water savings, approximately 3 MGD by the year 2020.

- The District should undertake a series of pilot or demonstration projects to determine the feasibility of some of the measures that are identified in Appendix A.

- Even if these measures prove feasible, they do not provide for the range of needs which include security and storage against deficiency, either in terms of quantity or reliability.

EBMUD's Urban Water Management Plan, the legislation that it sponsored requiring such plans, and expenditure of over $560,000 per year to achieve water-use efficiency will give the District a program that is in comparative terms more aggressive than all but a few small utilities that have had extreme water shortages. In order to continue and to expand the District's water conservation efforts, the Base Case program plus the additional measures described in this section are included in all of the major supply alternatives identified in this chapter.

Water Reclamation Projects

Most of the reclamation projects which the District found to be economically feasible have had several features in common: a large non-potable water demand, close proximity to a wastewater source, and minimal treatment requirements. This has resulted in the implementation of a reclamation program which currently saves nearly 5 MGD per year of potable water. Projects that may replace another 5 MGD of freshwater supplies are being evaluated. These projects are described below and summarized in Figure III-33.

Reclaimed water prices have been established for the Richmond Golf Course and the proposed Galbraith Golf Course project based primarily on recovery of District costs. This allowed the price to be significantly lower than the price of potable water and provided an incentive to the user to switch to reclaimed water. Due to the higher water quality requirements and subsequent treatment costs, the District's cost to implement the proposed Chevron project will be much greater. The proposed Chevron, and Galbraith Golf Course projects are described below.

GALBRAITH GOLF COURSE

In January 1987, a Facilities Plan for the Galbraith Golf Course Project was completed. This plan identified the project requirements and evaluated alternatives to reclaim up to 0.15 MGD (162 acre-feet/year) of secondary effluent from the San Leandro

Potential Reclamation Projects

Figure III-33

PROJECT	DESCRIPTION	STATUS	ANNUAL WATER SAVINGS (MGD)
Galbraith Golf Course	Reclaimed wastewater from the San Leandro Treatment Plant for irrigation of the Galbraith Golf Course in Oakland.	Service to start in Summer 1988	0.15
Chevron USA Oil Refinery Cooling	Reclaimed wastewater from West Contra Costa Sanitary District or the Richmond Municipal Sewer District for reuse in Chevron's recirculating cooling tower.	Pilot study complete; startup date is 1991	4.7
San Ramon Valley	Reclaimed wastewater from the Dublin San Ramon Services District for irrigation of golf courses, parks, playgrounds and schoolgrounds in the San Ramon Valley.	Planning Study	1.4

Water Pollution Control Plant (SLWPCP) for irrigation of 110 acres. The recommended project has an estimated construction cost of $323,000. Approximately half of this amount is expected to be funded by a low interest State loan.

The District is proceeding with the design of the facilities required for this project in order to meet project deadlines required by the loan program. It is expected that delivery of reclaimed water will begin in summer 1988.

The Galbraith Golf Course project takes advantage of the relatively low cost of treatment and delivery facilities required for landscape irrigation. The SLWPCP is located adjacent to the golf course and treatment consists of chlorination to meet the coliform standard and dechlorination to remove traces of chlorine which may be harmful to turf grasses.

The District signed an agreement to finance the construction of chemical addition, pumping, piping, and storage facilities to deliver treated reclaimed water to the irrigation piping system. The golf course will be required to pay the up-front costs to adapt to the use of reclaimed water. These costs include piping modifications necessary to separate the potable water systems from the irrigation systems and the posting of signs and printing of scorecards to inform golfers of reclaimed water use.

It is estimated that the District's cost of construction and operation can be recovered through the sale of reclaimed water at a price well below that of potable water (about 60 percent of the potable water price). This price makes the project economically attractive to the user because it offsets the costs to adapt to reclaimed water use and for maintenance of reclamation facilities on the golf course.

CHEVRON OIL REFINERY

The Chevron oil refinery has been identified as the largest single potential user of reclaimed water in the District's service area. The potable water demand which could be replaced by reclaimed water is 4.7 MGD (5261 acre-feet/year), an amount representing the water use of approximately 20,000 average households in the Richmond area. This large demand, and the fact that the refinery is located within three miles of two sources of wastewater, contribute to the economic feasibility of this project.

The basic project features are:

- A project costing a total of $14.6 million ($12.0 million to be spent by EBMUD and $2.6 million to be spent by Chevron) can result in the replacement of 4.7 MGD of potable water with 5.4 MGD of reclaimed water.
- The reclaimed water will have lower quality, cannot be recycled as many times, and will require Chevron to incur higher refinery operating costs.
- The financing program would provide for the sale of reclaimed wastewater to Chevron at a 30 percent reduction from the retail water rate due to the need to purchase more reclaimed water to replace potable water and the extra capital and operating costs to the refinery to use reclaimed water.

The major difference between this project and the golf course irrigation projects is the more stringent water quality requirements. In order to allow reclaimed water to be used in recirculating cooling towers, it is necessary to reduce the concentration of certain contaminants which cause scaling, corrosion, and fouling of heat exchangers. This can be accomplished by the addition of chemicals in advanced wastewater

treatment (AWT) processes. AWT processes include the addition of lime and soda ash to the water for softening or the reduction of calcium and phosphates which contribute to scaling. Although relatively expensive, AWT would bring the recycle rates for the cooling towers close to the rates provided by using potable water.

In addition to the cost of AWT, the use of reclaimed water would require Chevron to change to a more expensive type of cooling water treatment program to control the chemical stability of the water recirculated in the cooling towers. The use of this treatment program is well established at many other facilities; however, because Chevron has limited experience with it, the start-up period would require extra time and attention by maintenance and operation personnel. Other costs to Chevron would be for new pipelines, chemical metering equipment, and water quality monitoring instrumentation.

SAN RAMON VALLEY

Another area where the District may have the opportunity to implement reclamation is in newly annexed areas. In the San Ramon Valley, there are areas which are being developed that could be the first at the District to have a dual water system (separate potable and reclaimed water pipelines). Reclaimed water could be used for irrigation of community landscaped areas. The cost of such facilities could be recovered from System Capacity Charges in much the same manner as are the costs of potable water facilities. Preliminary estimates indicate that the cost of these facilities would be high.

In August 1983, EBMUD, Dublin San Ramon Services District (DSRSD), and Alameda County jointly sponsored a study to investigate the potential for wastewater reclamation in the San Ramon Valley. The market survey identified 18 potential irrigation sites totaling 850 acres, including golf courses, greenbelts, parks, and schools. The recommended project focused on eight irrigation sites, totaling 488 acres. Parks and schools were eliminated because a higher level of treatment is required at a subsequently higher cost. This project has the potential to reduce the average annual demand for potable water by 1.4 MGD (1631 acre-feet/year).

The initial evaluation of the economic feasibility of this project showed that it was linked to the selection of the project by the local wastewater management agency disposing of highly treated wastewater to local creeks. This was because, if a reclamation project was selected, the Tri-Valley Wastewater Authority (TWA) would be responsible for the majority of the treatment and delivery costs required for reclamation. The District's costs would be limited to the lateral pipelines and pumping plants to serve the individual users.

Although it has become apparent that TWA will be proceeding with another disposal alternative and the project costs have increased to about $1000 per acre-foot, the project may still be considered if additional users can be found. However, the 1.4 MGD potential reclaimed water use for this project has not been included in projected additional reclaimed water use of 5 MGD used in this report.

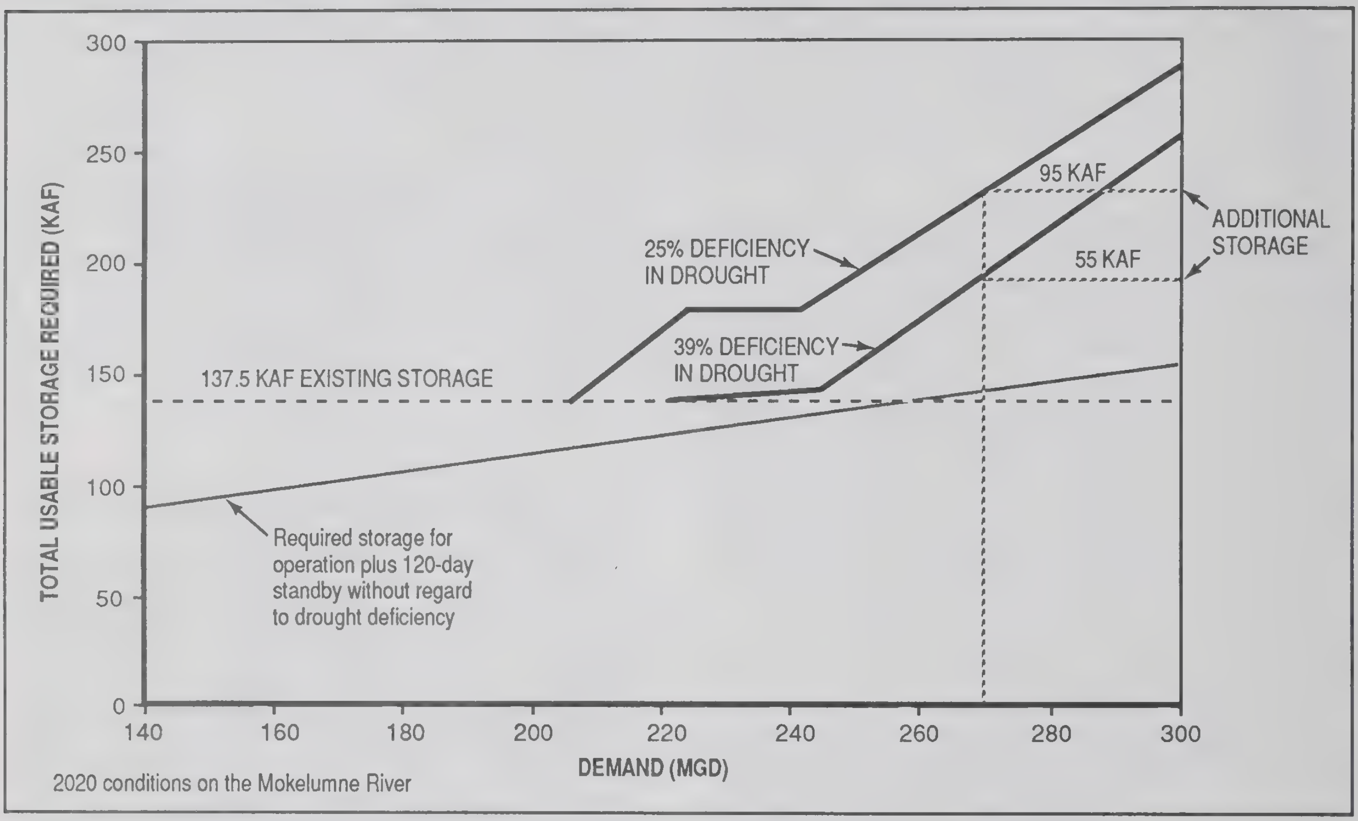
Water Banking (Additional Terminal Storage)

This section examines how additional terminal storage would help meet dry year shortages. However, it is important to note that additional terminal storage could also help meet the need for security against outages. The benefits of additional storage to the security of the water supply system are discussed in Chapter II.

EBMUD's water supply of 325 MGD from the Mokelumne River is adequate in most years to meet the current demand of about 220 MGD and the projected demand of 270 MGD in 2020. However, during drought periods like 1976-77 the supply is less than normal demand, in which case storage on the Mokelumne River and in the local service area is used to make up the difference together with planned water use restrictions. The existing water supply system can accommodate a percentage reduction in demand like that experienced in 1977 (39 percent) only until demand reaches about 240 MGD around the year 2000. A less severe level of rationing, such as a 25 percent reduction, cannot be accommodated at current demand with the existing system. Additional terminal storage would provide the supply necessary to accommodate the projected demand of 270 MGD in year 2020 and limit the level of rationing to 25 percent. The amount of storage needed depends on the level of normal demand and the planned restrictions on water use, as shown in Figure III-34.

As in the case of many other California Central Valley rivers, offstream storage which "banks" wet season flows can provide for enhanced flows in the lower Mokelumne River to meet downstream obligations to prior water right holders and fish flows that are prescribed in the District's water rights permits and numerous agreements with other Mokelumne interests, including the California Department of Fish and Game. The Department of

Terminal Storage Needed to Meet Water Demand During Drought Figure III-34



Fish and Game and fishermen's organizations have complained that these commitments are being violated; the Department is conducting a comprehensive fishery study of the lower Mokelumne River, which is likely to result in recommendations for modified releases from Camanche. While EBMUD's obligation to deliver high quality drinking water is its first priority, the District is well aware of its other obligations on the river. The District uses these required releases to generate hydroelectric power. The greater the amount of storage within the District's system, the greater the flexibility that the District will have to conduct its operations on the Mokelumne for the benefit of instream uses, such as fish enhancement.

Historically, the District has released an annual average of 95,000 acre-feet into the Mokelumne River to meet its downstream obligations to Woodbridge Irrigation District. This has provided significant flows for fish above the District's obligation. It also benefits groundwater pumpers whose wells are recharged with the excess flows in the river.

Bureau of Reclamation (USBR) Contract

In December 1970 the District contracted with the U.S. Bureau of Reclamation (USBR) for a supplemental supply of Central Valley Project (CVP) water. The point of delivery is on the Folsom South Canal near Grant Line Road, about 12 miles south of the American River. The aqueduct system necessary to convey water from the canal directly to EBMUD's service area or to the Mokelumne Aqueducts for delivery to the EBMUD service area is the District's responsibility, and such facilities have not yet been constructed due to litigation.

The contract is for 150,000 acre-feet annually (AFA) or about 134 MGD. This amount, however, can be reduced by the USBR in drought years. Such contract allotment reductions occurred during the 1976-77 drought. In April of 1977, the USBR informed the District that its 1977 contract allotment would be 50 percent of its contract amount. In November 1977, the USBR notified the District that if the drought continued, the District's 1978 entitlement would be reduced a total of 75 percent. However, the drought ended, and such severe restrictions were not imposed.

In 1972, the Environmental Defense Fund, along with the Save the America River Association and others, brought suit against EBMUD. They alleged that the delivery of American River water via the Folsom South Canal to EBMUD customers would cause severe harm to lower American River in-stream uses, and that EBMUD should divert water below the confluence of the American and Sacramento Rivers in

order that beneficial uses made of water in the lower American River will not be diminished. Sacramento County joined as a co-plaintiff shortly afterward, even though the county had been represented in the negotiations which led to the signing of the contract.

The use of water under EBMUD's contract via the Folsom South Canal would increase the supply to EBMUD customers in normal years and could help reduce the severity of rationing in a drought. In the current litigation over the contract, EBMUD has proposed to avoid taking water from the Folsom South Canal when minimum flow standards are not met in dry years in the lower American River. This could result in EBMUD not taking delivery of water in a drought like 1977. To deliver the water, facilities would have to be constructed from the Folsom South Canal to the Mokelumne Aqueducts.

The costs for this alternative will depend on the route of the delivery pipeline and range from $105 million to $255 million. Implementation of the American River supply is currently delayed by the litigation; therefore, meeting EBMUD's quantity needs with the USBR contract is an alternative which is not immediately available.

Interties

As discussed in detail in Chapter II, the amount of supply available from interties would be limited and uncertain. No utility has a significant long-term surplus that EBMUD can depend on for the required water quantity and outage time. In addition, water rights and environmental issues associated with any change in source or place of use could be significant. Any interties with Hetch Hetchy system might help in the event of a Mokelumne supply outage, if the water were available; but this is an uncertainty. If water were available, a major intertie would cost in the order of $100 million. If Delta water were usable, EBMUD could take delivery of its American River contract instead of going through an intertie with CCWD. An intertie with the South Bay Aqueduct could cost over $400 million for conveyance and treatment facilities. Studies can be undertaken to evaluate interties with other agencies but the amount of supply available from interties would be limited and uncertain.

Other Additional Supply Sources

EBMUD's original decision to select the American River as the source for a supplemental supply of water and the subsequent negotiations which resulted in the execution of the USBR Contract in 1970 were based primarily on the quality of water available and the certainty of the water supply under a contract with the USBR. A review of other suggested sources which were considered before and since that decision shows that there are no feasible alternatives to the American River. The American River is still the best available source of water. The following is a discussion of the other suggested sources of supply.

DELTA WATER SUPPLY

In late 1977 and early 1978, EBMUD received an emergency delivery of approximately 25,000 acre-feet of water by pumping from Middle River in the Delta. This was necessary because the 1976-77 drought significantly reduced EBMUD's Mokelumne supply.

However, the Delta has the major disadvantage of being a lower quality source than EBMUD's Mokelumne supply, particularly during droughts when the flow from the Sacramento River is not sufficient to repel the intrusion of sea water from San Francisco Bay. There is a concern about future public health risks associated with contaminants like trihalomethanes. Furthermore, EBMUD's water treatment facilities and processes are based on using a high quality source of water and would require extensive capital improvements to be able to handle Delta water. In 1977, EBMUD had first-hand experience of the adverse effects which can result from the use of Delta water. These problems are described later in Chapter IV.

Any supply from the Delta would have to be obtained under contract with the State of California or the USBR, and the amount would be subject to negotiation of an agreement. The estimated cost of the additional facilities necessary to treat the lower quality water is about $370 million, in 1988 dollars. This cost is much greater than the estimated $105 million needed to implement the supplemental supply under the USBR contract. In addition, a diversion facility in the Delta would have potential impacts on the fishery resources and would require extensive screening facilities to minimize these impacts.

Because of the water quality problems and associated high treatment costs, the Delta is not a feasible planning alternative, especially since one of the District's primary goals is to provide the highest quality water to its customers. However, this does not preclude the use of Delta water for short periods of time in an emergency when there is no other option available.

WOODBRIDGE IRRIGATION DISTRICT (WID) EXCHANGE

Agreements between EBMUD and the Woodbridge Irrigation District and Woodbridge Water Users Conservation District provide that EBMUD will release enough water from Camanche Reservoir each year so that a Permanent Regulated Base Supply of 39,000 to 60,000 acre-feet, depending on inflow to EBMUD's reservoirs, is available for use by the Woodbridge districts; with sufficient additional releases through 1992 so that an Interim Supply of 26,855 to 56,700 acre-feet, depending on inflow and EBMUD's diversions, is also available to those districts. These agreements recognize the relative rights to Mokelumne River water held by each district.

In the Woodbridge exchange concept, EBMUD would provide a water supply to the Woodbridge districts from some other source in exchange for a commitment by those districts to reduce their Mokelumne River diversions correspondingly. The other source could be from the Eastern Delta. A small amount of water could be available from possible groundwater sources in the Woodbridge area. However, many areas in the lower Mokelumne River are already experiencing groundwater overdrafts. Nothing would be gained by such an exchange in terms of the Interim Supply, which can simply be terminated under provisions of the agreements; but up to 39,000 acre-feet of Permanent Regulated Base Supply water might be saved in dry years through an exchange, if flows in the lower Mokelumne River can be reduced by 39,000 acre-feet in dry years without major impact to fish. The estimated capital cost is approximately $25 million if water were pumped to the Woodbridge districts from nearby Beaver Slough.

The Woodbridge districts have not expressed an interest in such an exchange. Nor is it likely that agencies concerned with the river's fish and wildlife would permit major additional dry year flow reductions. Attempting to implement a Woodbridge exchange without the consent of all interested parties, including other Mokelumne water users, could trigger an adjudication of all Mokelumne River water rights, with unpredictable consequences. For these reasons, an exchange with the Woodbridge districts is considered impractical.

MOKELUMNE RIVER PROJECTS

The suggestion has been made that EBMUD could construct one or two new dams on the Mokelumne River above Pardee Reservoir to increase the yield from Pardee Reservoir. However, EBMUD is expressly prohibited by a 1958 agreement with Amador County from filing any new applications on the Mokelumne River to take additional water for consumptive use.

Furthermore, when EBMUD proposed the Middle Bar and Railroad Flat projects on the Mokelumne River, Amador County and the Amador County Water Agency filed a lawsuit against EBMUD for breach of contract even though the projects were to be used for hydroelectric purposes only. In addition, legislation has been introduced to create a "river recreational area" in the area that would have been inundated by the Middle Bar project. The intent of this legislation was to preclude future development in any river recreational area. This alternative has serious legal obstacles.

STANISLAUS RIVER PROJECT - NEW MELONES RESERVOIR

The New Melones Dam and Reservoir on the Stanislaus River was completed in 1980 and would have a firm yield of 180,000 acre-feet in the year 2020. However, the water requirements of users within the Stanislaus river basin is projected to be about 131,000 acre-feet. The remaining 49,000 acre-feet of yield is not available because it has already been allocated to other areas within the Central Valley Project.

COSUMNES RIVER PROJECT

The Cosumnes River Project Association has had plans for several years to develop the yield of the Cosumnes River. The water rights to most of the remaining unappropriated Cosumnes River water are held by the State. However, the Cosumnes River has been named a candidate for the Wild and Scenic River designation, making the construction of any project on the river difficult.

Figure III-35 summarizes the alternatives for supply.

Alternatives to Reduce Water Shortages

Figure III-35

ALTERNATIVE	REMARKS
1. Do Nothing	Continue the problem of water shortages during drought periods with increasing severity of rationing required in second dry year as demand increases in the future.
2. Water Conservation (Additional Measures)	Continue existing program and implement additional feasible measures which would save a total of 7 MGD by 2020 ($0.6 million per year); this would not be sufficient to solve the problem of shortages nor to reduce the severity of rationing.
3. Water Reclamation (Additional Projects)	Continue existing program and implement additional feasible projects which would save about 5 MGD by 2020 ($15 million); this would not be sufficient to solve the problem of shortages nor to reduce the severity of rationing.
4. Water Banking (Additional Terminal Storage)	Additional storage of 95,000 acre-feet would provide capability of surviving a drought period with rationing limited to 25% during the second dry year, at a projected demand of 270 MGD in the year 2020 ($115 to $146 million).
5. USBR Contract	Implementation of the USBR contract by connection to the Folsom South Canal would, in conjunction with storage, help reduce the severity of rationing in a drought; implementation is delayed by litigation, therefore this is not an available alternative.
6. Interties with Other Agencies	No water agency has surplus water in a drought that EBMUD could depend on for shortages or reducing the severity of rationing, except those agencies with water supplies from the Delta; if use of Delta water is considered then EBMUD could pump directly from the Delta (see next alternative)
7. Delta Water Use	Water from the Delta is adequate in quantity, but its quality is inconsistent with EBMUD's treatment systems (improvements would cost $370 million) and its policy on water quality; water quality in the Delta is at its worst in dry years; experience shows that use of Delta water, even for short periods, should be avoided as a solution for the problem of shortages.
8. Exchange with Woodbridge Districts	Up to 39,000 acre-feet of additional Mokelumne water could be available if the Woodbridge Districts were to reduce their Mokelumne diversions in exchange for some other source; one possible source could be the Delta (about $25 million for facilities) or a small amount from groundwater sources in the Woodbridge area; feasibility and institutional arrangements are uncertain; this water could help but would not solve the problem of shortages.

Chapter IV
Safety and Health:
Maintain High Quality Water

BACKGROUND

The District has had a historic commitment to provide its customers a drinking water supply which is safe, reliable, and free from taste and odor problems. When the East Bay Municipal Utility District was formed in the 1920's, it secured a high quality source from the Mokelumne River. Less expensive sources from the Sacramento-San Joaquin Delta and local groundwater were available, but the founders believed that the public would be served better by choosing a source of higher quality.

In its efforts to meet or exceed all present or potential state and federal standards, it is the District's policy to:

- Choose the highest quality source available when selecting or improving the water supply system.
- Take active measures to protect the supply from pollution.
- Implement the treatment improvements necessary to minimize contaminants and to eliminate taste and odors by providing water of the highest quality.

The District's selection of the Mokelumne River as its primary water source exemplifies EBMUD's commitment to high quality water supplies. To protect this high quality source, EBMUD owns 42,000 acres of watershed lands and maintains a watershed management program including watershed reconnaissance, water quality monitoring, and land management and acquisition. The District has embarked on a $35 million treatment improvement program aimed at modernizing its treatment plants and improving its taste and odor control capabilities by the addition of ozone and granular activated carbon at its Sobrante and Upper San Leandro Filter Plants. The District continues to pursue advanced treatment technology to assure compliance with future drinking water regulations and to minimize the amount of chemicals required for water treatment.

Problem

A primary concern is the need, discussed in Chapters II and III, for EBMUD to increase its supply availability to have high quality water during outages and periods of drought. During these times, when the Mokelumne supply could be totally severed or severely limited, alternative supplies must be used. Alternative supplies from the Delta present numerous water quality problems. Based on its experiences with the Delta water during the 1976-77 drought, EBMUD's specific concerns include excessive salinity, high trihalomethane formation potential (formation of cancer-causing compounds), taste and odors, and limitations of the District's system in treating the Delta supply.

There is also a need to protect the District's existing sources from potential contamination and pollution. EBMUD protects the quality of its existing supply by monitoring and, where possible, controlling activities within the watersheds that could lead to contamination.

EBMUD provides very high quality water to its customers although summertime algal growth regularly causes taste and odor problems in the El Sobrante and San Leandro areas. While not posing health and safety risks, taste and odor problems are a serious aesthetic and economic problem because customers will seek more expensive alternatives including bottled water and home treatment devices.

EBMUD's treatment plants range in age from 21 to 67 years and are in need of modernization. Because of current and anticipated regulatory requirements, EBMUD needs to continue to pursue advanced water treatment technology.

Supplies meeting today's water quality standards will not necessarily meet future health requirements. In selecting new sources of water, EBMUD needs to obtain the best water source available. EBMUD has determined that the American River is the best available supplemental source.

Importance of Source

Both the Federal Environmental Protection Agency (EPA) and the State of California Department of Health Services (DOHS) recognize the significance of high quality source waters as they relate to the quality of treated water consumed by the public. DOHS has been designated by EPA as the "Primacy Agency" in California with the responsibility for promulgation and enforcement of drinking water standards. DOHS, in its recently published "Guidelines for Treatment of Surface Waters for Domestic Use" (April 1986), reiterated its long-standing policy that:

> "Water utilities should seek to obtain the cleanest water source practical and provide all reasonable protection of the supply from any known or potential contamination hazard."

In its recent Policy Statement on Water Quality, the American Water Works Association stated its support for the principle that water of the highest quality should be delivered to all consumers. The Association stated that: ". . .water should come from the highest quality source of supply available and be appropriately treated to meet supply industry criteria."

A major emphasis of new drinking water regulations will be on the reduction of organic chemicals. The majority of organic compounds that exist in public drinking water supplies have not yet been identified and are of unknown health significance. Therefore, supplies meeting today's water quality standards will not necessarily meet future public health requirements. It is important to note that trihalomethanes (THMs) were only discovered in drinking water in the early 1970's. Other contaminants which may also pose significant health risks are likely to be discovered in the future. These unknowns, coupled with the problems which are already known, provide an overwhelming argument for choosing the best available water source.

The high quality of the District's Mokelumne River (Pardee Reservoir) supply is exemplified in Figure IV-1. The significance of the parameters shown in Figure IV-1 is discussed in a following section on "Water Quality and Drinking Water Regulations".

WATER TREATMENT REQUIREMENTS

The amount of treatment that is required for a supply depends upon the quality of that supply and the degree to which its watershed is protected from pollution. Because of the high quality of Pardee Reservoir and the protected nature of its watershed, minimal treatment processes are required. These include coagulation, filtration, and disinfection, which are commonly referred to as direct filtration.

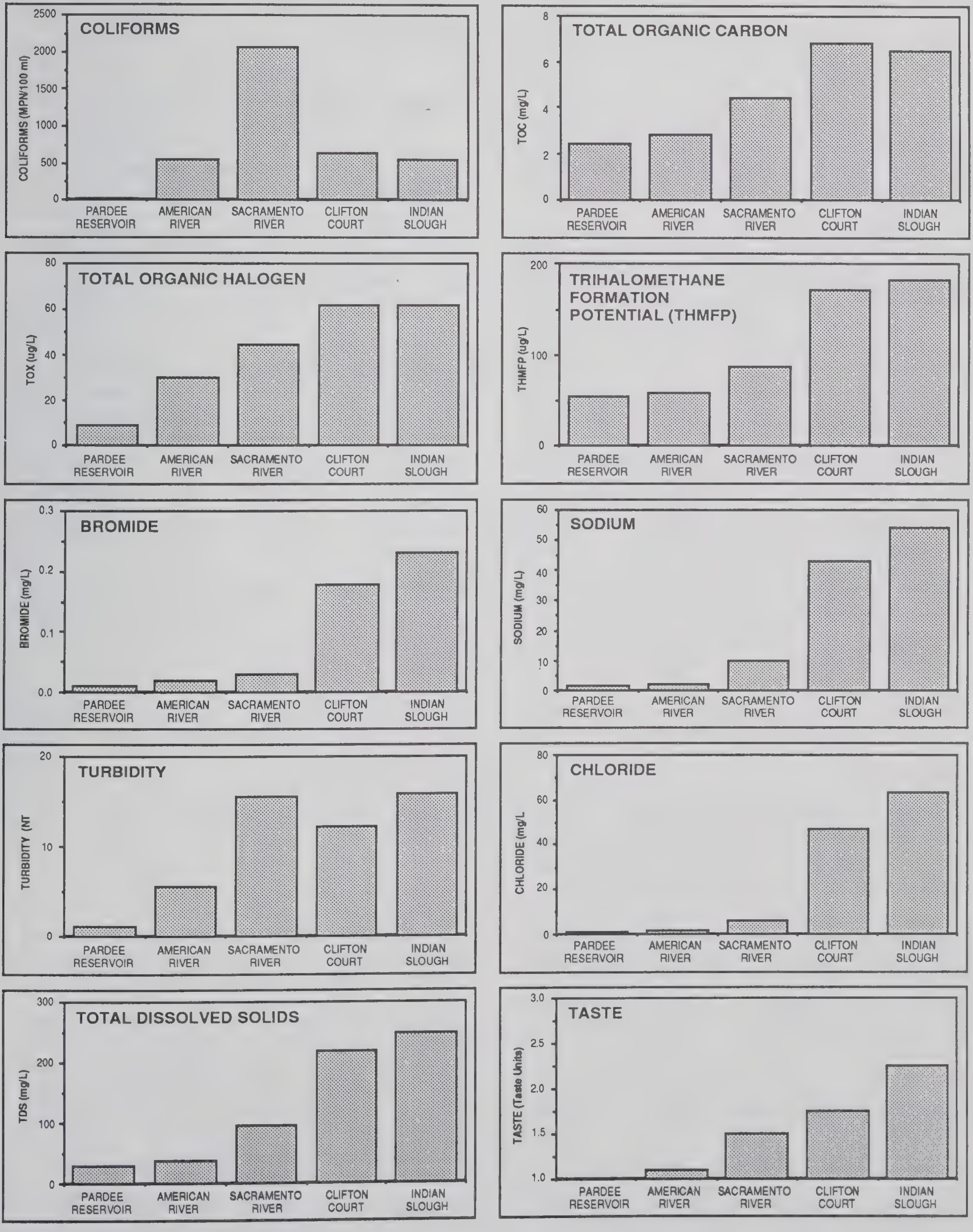
Urban development on a water supply watershed increases the probability of pollution of the water supply. These effects are described in a 1986 EBMUD report entitled "Urban Development and Runoff Effects on Water Quality" (EBMUD 1986). Water quality degradation associated with urban development is due to soil erosion caused by construction activities, sedimentation in streams and reservoirs and runoff from urban areas. Urban runoff causes increased risk of sewage and toxic spills, nutrient loadings which lead to taste and odors, organic loadings which lead to increased trihalomethanes, toxicity concerns due to contributions of metals and organics, increased contamination by disease-causing (pathogenic) organisms and increased soil erosion and reservoir siltation. Intensive agricultural use of land on a water supply watershed will also increase the probability of pollution of the water with chemicals including pesticides and herbicides.

As urban and agricultural development occurs, increasing levels of treatment are required to assure the safety of the water supply from both a health and aesthetic viewpoint. These additional treatment processes will substantially increase the cost of treating a supply for public consumption. Additional treatment facilities usually include aeration, flocculation, and sedimentation with increased water treatment chemical usage. These processes plus those in direct filtration are commonly referred to as conventional, or full treatment.

EBMUD operates six water treatment plants; three direct filtration plants which treat water directly from Pardee Reservoir and three full treatment plants which treat Pardee Reservoir water and local runoff which has been stored in local East Bay reservoirs. EBMUD's water treatment system is summarized in Figure IV-2.

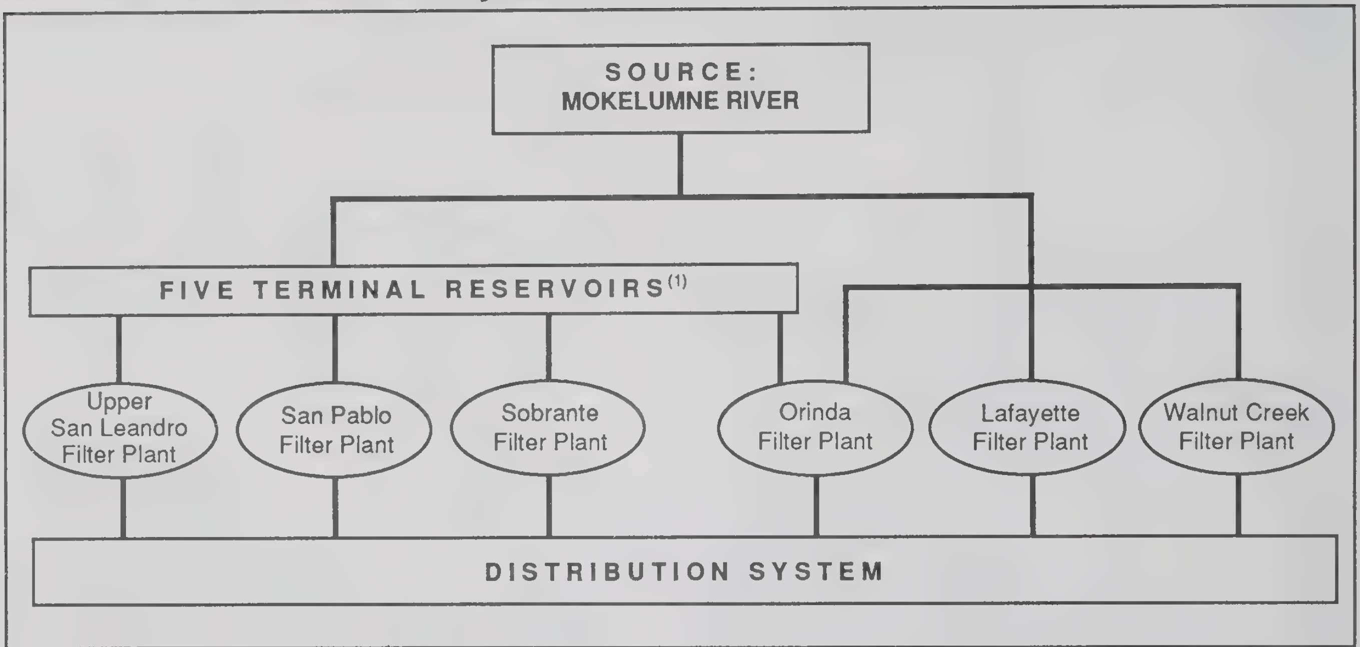
EBMUD Raw Water Quality Monitoring Program Summary (August 1983—October 1987)

Figure IV-1



EBMUD Water Treatment System

Figure IV-2



SOURCE WATER	FILTER PLANT	TYPE OF TREATMENT	YEAR OF CONSTRUCTION	CAPACITY MGD
Pardee Reservoir	Walnut Creek	Direct Filtration	1967	80
Pardee Reservoir	Lafayette	Direct Filtration	1953	42
Pardee Reservoir Briones Reservoir	Orinda	Direct Filtration	1935	175[2]
San Pablo Reservoir	San Pablo Sobrante	Full Treatment Full Treatment	1921 1965	60 60
Upper San Leandro Reservoir	Upper San Leandro	Full Treatment	1927	83

NOTES:

[1] Chabot and Lafayette Reservoirs, small standby reservoirs, would only be used during extreme emergencies.

[2] Improvements under construction at Orinda Filter Plant will increase its capacity to 200 MGD by December 1988.

Chabot Filter Plant, a small plant constructed in 1890, is no longer in use.

Briones Reservoir can supply the entire system on an emergency basis.

As EPA continues to promulgate additional drinking water standards, even more treatment processes may be required. Use of the higher quality sources will minimize the necessity for costly facilities and reduce the amount of chemicals to be used for water treatment.

IMPACT OF TERMINAL STORAGE ON WATER QUALITY

Mokelumne water that is not treated by the District's direct filtration plants is stored locally in the East Bay in terminal reservoirs before treatment. In addition to the degradation caused by urban runoff into these reservoirs, other factors including reservoir depth and detention time impact water quality.

The depth of a reservoir plays an important role in water quality control. During the winter and spring, runoff into the reservoir increases the water's turbidity (suspended particulate matter) and resultant treatment costs. During the summer and fall, the turbidity settles. As the water warms and clarifies, algae will grow in the upper portions of the reservoir. If water is taken from the upper portions of the reservoir, taste and odors, which can be very difficult to remove, result. If water is drawn from the lower portions of a

reservoir the higher turbidities found there increase treatment costs and anoxic conditions at the bottom may cause offensive taste and odors. Ideally a reservoir should be deep to allow the selection of water from various elevations in the reservoir to minimize taste and odors and treatment costs.

The detention time of a water in a reservoir can affect the level of mineralization of the water. If a water low in minerals is stored in a reservoir it dissolves minerals in the underlying strata resulting in higher levels of minerals in the water. As the detention time increases, the mineral content of the water will increase until it reaches an equilibrium level.

A summary of the water quality and some of the factors affecting water quality in the District's terminal reservoirs is shown in Figure IV-3.

Briones Reservoir provides a high quality supply because there is no urban development on the watershed and it is deep, 194 feet at the outlet tower. For these reasons, Briones water can be treated by the direct filtration process at Orinda Filter Plant. Briones Reservoir is used primarily for standby and consequently has a detention time of 7.2 years which causes the mineral content to increase to a moderate level.

San Pablo and Upper San Leandro Reservoirs, because of the extensive urban development on their watersheds and their shallow depths at the outlet towers, are subject to wide swings in water quality and persistent taste and odors in the summertime. The full treatment required for these reservoirs, although capable of removing turbidity at higher costs, has not been able to eliminate taste and odors. San Pablo Reservoir, because of its shorter detention time, has a lower mineral than the other terminal reservoirs.

Analysis of the water quality aspects of the various terminal reservoir alternatives under consideration is included in Chapter V.

EBMUD EXPERIENCE WITH DELTA WATER

While the storage of Mokelumne water in terminal reservoirs helps to buffer the effects of urban runoff, the addition of other imported supplies can have a tremendous effect on the quality of the terminal reservoirs.

During the California drought of 1976-77, EBMUD had first-hand experience with treating Delta water on an emergency basis for municipal supply. Delta water was mixed with existing supplies and served to all customers in the EBMUD service area. The supply was withdrawn from Middle River upstream of Clifton Court Forebay. Middle River water was also pumped to Contra Costa Water District because of high salt levels in the Contra Costa Water District supply from Rock Slough (near Indian Slough in the west Delta). The high salt levels were caused by sea

EBMUD Terminal Reservoir Water Quality

Figure IV-3

PARAMETER*	AVERAGES			RANGES		
	BRIONES	SAN PABLO	UPPER SAN LEANDRO	BRIONES	SAN PABLO	UPPER SAN LEANDRO
Total Dissolved Solids	172	135	175	167—190	84—150	147—210
Chloride	8	8	13	6—10	6—11	11—15
Sodium	17	11	16	15—19	6.4—14	13—20
Bromide	0.10	0.08	0.12	0.03—0.2	ND—0.2	0.04—0.3
THM Formation Potential	0.083	0.176	0.186	0.070—0.126	0.077—0.324	0.019—0.382
Turbidity (NTU)	0.87	8.9	5.4	0.4—9	0.8—50	0.6—70
Taste (taste units)	1.2	1.1	1.2	1—2	1—2	1—2
Odor (odor units)	1.3	1.6	1.5	1—2	1—2	1—2
Coliforms (org/100 mL)	33	332	177	0.9—170	4.9—1700	23—700
Depth of outlet tower, feet	194	94	79			
Average detention time, years	7.2	0.7	1.1			
Watershed area, square miles	9	23	30			
Urban areas, square miles	0	6.1	7.8			

*All values as averages in mg/L unless noted.
Data excerpted from "Water Quality Study," by J. M. Montgomery Engineers, 1983.

water intrusion into the Delta due to the absence of sufficient flows in the Sacramento River to repel brackish water from the ocean.

Because of its concern for trihalomethanes (THMs) (cancer risk) and sodium (hypertension and high blood pressure risk), DOHS limited the use of Delta water. EBMUD also experienced taste and odor problems from putting Delta water into two large local storage reservoirs. The amount of Delta water in San Pablo and Upper San Leandro Reservoirs rose to approximately 1/3 of total storage by the time the drought ended.

THMs presented the most serious health concerns. Figure IV-4 illustrates the influence of Delta water on Upper San Leandro Reservoir. The figure shows that the THM levels more than doubled following the introduction of Delta water to Upper San Leandro Reservoir. Average trihalomethane levels rose to approximately 70 micrograms per liter (ug/L). The drinking water standard is currently 100 ug/L but serious consideration is being given within EPA to lowering the standard. The new standard will probably be in the range of 10 to 50 ug/L, significantly below the levels experienced by EBMUD when using Delta water.

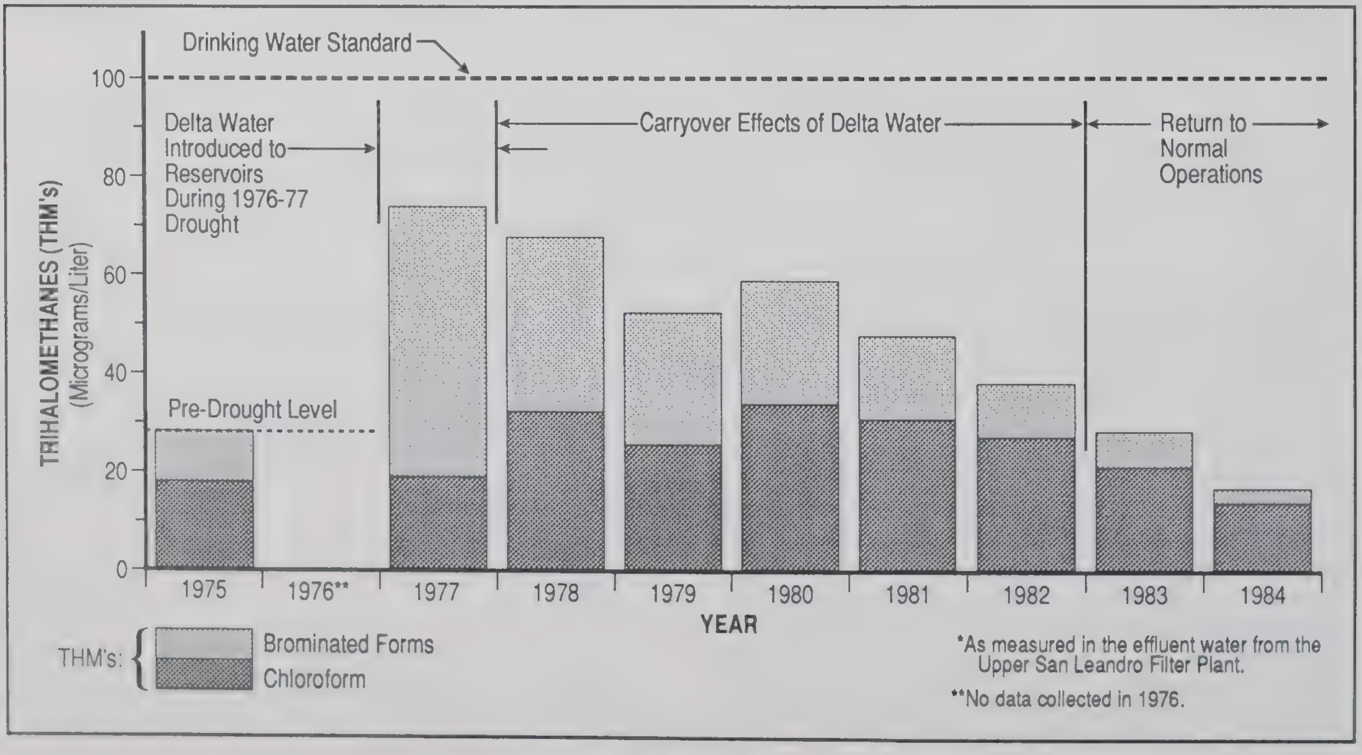
Two important facts emerged regarding the effects of Delta water on THMs in Upper San Leandro Reservoir. The first was that it took approximately 5 years for the THM influence of Delta water to be flushed out of the reservoir. Secondly, a very high proportion of the THM's were brominated forms. EBMUD data confirmed the finding of high bromide content in the Delta. These data are summarized in Figure IV-4. Brominated THMs are of significant concern because they are suspected to be more potent as carcinogens than chloroform (the most commonly occurring THM). The elevated bromide levels are caused by sea water intrusion, particularly in dry years, when Sacramento River water is not adequate to repel the intrusion.

EBMUD experience with Delta water during the drought confirmed that use of a lower quality source water can cause significant water quality and treatment problems. Contra Costa Water District (CCWD) normally takes its supply from the Delta at Rock Slough. During the Andrus Island flood in 1972, Delta water quality was degraded by salt water intrusion. CCWD requested emergency supplies from EBMUD to improve its water quality. During drought or flood, it is clear that Delta water would not meet EBMUD's need for high quality water.

Protection of the Source

EBMUD protects the high quality of its sources in three ways:

Impact of Delta Water on Terminal Reservoirs* **Figure IV-4**



*As measured in the effluent water from the Upper San Leandro Filter Plant.

**No data collected in 1976.

WATERSHED RECONNAISSANCE

EBMUD patrols its watershed areas on a daily basis to detect fires, discourage trespassers, and regulate lease holders. All major proposed projects within the District's watersheds or adjacent to District property are reviewed so that their influence on watershed lands can be assessed. The District conducts periodic sanitary surveys of its watersheds in which all potential threats to water quality are evaluated. The District also maintains close contact with local officials so that they will contact the District immediately of any activities which could adversely affect the watershed.

WATER QUALITY MONITORING

The District maintains an extensive routine monitoring program to ensure that the quality of its sources is not deteriorating. A complete set of laboratory analyses are performed annually on all of the District's source waters. Additionally, some analyses are performed monthly, and others are performed every two hours at the treatment plants for process evaluation.

LAND MANAGEMENT AND ACQUISITION

EBMUD's management of its watershed lands ensures that only those activities which are compatible with water quality preservation occur within the watershed. The management program includes vegetation control, erosion control, and land-use planning.

Vegetation control, to reduce fire hazards, is accomplished as much as possible through livestock grazing or mechanical means. The use of herbicides is kept to a minimum to prevent contamination of the reservoirs by runoff, and even then only quickly-decomposing, locally-applied herbicides are used.

To prevent the runoff of silts into the reservoirs, erosion is controlled with construction of silt retention structures and repair of erosion gullies. In addition, EBMUD cooperates with local governments to ensure that nearby grading projects do not cause erosion.

Land use planning is necessary to prevent adverse impacts on water quality from influences such as urban pollution and septic tank leakage and sewer overflows to surface streams. The remedies employed by the District include: land zoning to prevent excessive development, requirement of mitigation measures for development, support of septic tank regulations, and land exchange/purchase to ensure that key watershed lands are protected and not used in a manner that would threaten water quality and public health.

Water Quality and Drinking Water Regulations

A summary of selected constituents from EBMUD's raw water quality monitoring program results is shown in Figure IV-1. The summary compares the water quality at the following sites: Mokelumne River at Pardee Reservoir, the American River at Nimbus Dam, the Sacramento River at Green's Landing, and the Delta at Clifton Court Forebay and Indian Slough. The selected sampling locations are shown in Figure IV-5. As that figure shows, the Mokelumne River is a superior source.

In 1986, the Federal Safe Drinking Water Act was amended to more than triple the number of regulated contaminants over the following three years. The EPA has been directed by Congress to promulgate national primary drinking water regulations for 83 contaminants by June 1989. These contaminants were listed in the Federal Register on March 1982 and October 1983 and are shown in Figure IV-6. The EPA is now preparing new drinking water regulations to implement these amendments. The emphasis in the new regulations will be on reduction of organic chemicals in drinking water, filtration of surface water supplies, and disinfection of all water supplies.

Figure IV-7 illustrates the fact that the number of water quality standards being promulgated is accelerating. Even with the increased efforts at setting standards, a vast number of organic compounds are not yet regulated.

HEALTH RISKS OF SPECIFIC SUBSTANCES

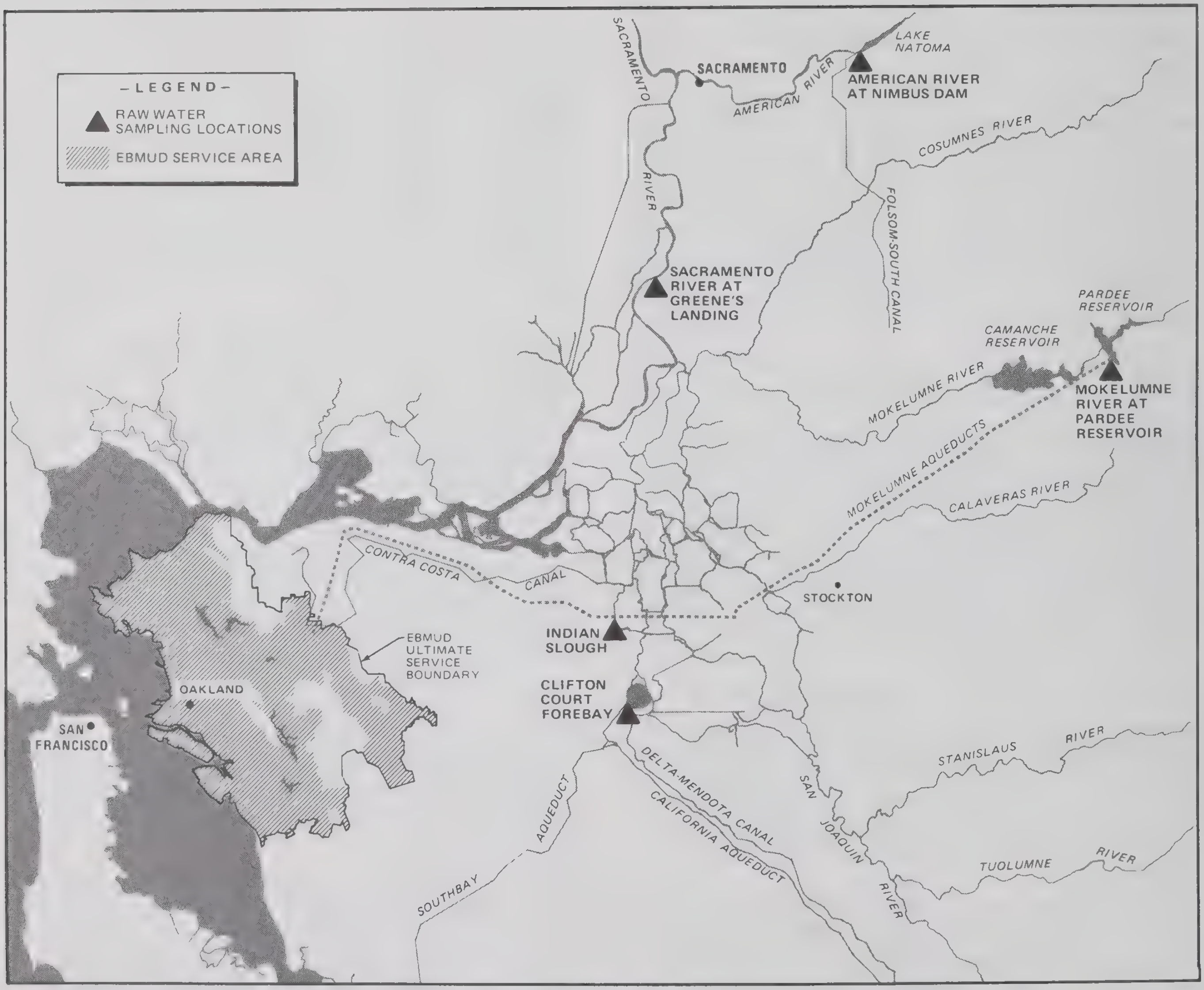
Priority is given to the health-related aspects of water quality for which "primary" standards (maximum contaminant levels, or MCLs) were established by EPA and which are enforced by DOHS. Most of the contaminants for which primary standards were established have not been detected in the District's raw or treated waters, and those that have been are presently at levels well below the MCLs. Current values for these standards are listed in Figure IV-8, along with the average values determined for the District's treated water.

The following paragraphs summarize a selection of constituents considered to be of particular importance in regard to public health effects.

Pathogens (disease-causing microorganisms) have historically been the primary impetus to treat water. Until the twentieth century, waterborne protozoa, bacteria, and viruses caused disease outbreaks, resulting in widespread illness and death. With the advent of disinfection, such outbreaks have been

Source Sampling Locations

Figure IV-5



substantially eliminated. Disinfection continues to be a critical element of water treatment due to recently identified concerns regarding the potential contamination of water supplies with two protozoa, Giardia and Cryptosporidium.

Coliform bacteria are used as an indicator of the potential presence of pathogenic organisms in water. As can be seen in Figure IV-1, average total coliform levels in Pardee Reservoir are very low.

Total Organic Carbon (TOC) is the parameter most commonly used as an indicator for organic compound content in water samples. Little is known about the health risks that organic compounds pose. It is therefore safer to minimize the concentration of all of these organic compounds, as represented by TOC. As shown in Figure IV-1, the TOC concentration in Pardee Reservoir is about 2-½ times less than that in the Delta.

Synthetic Organic Compounds (SOCs) may occur in water as the result of contamination from hazardous waste sites and industrial and agricultural discharges. The EPA has proposed MCLs for several volatile SOCs based on their carcinogenicity and has identified more for probable regulation. The levels of volatile SOCs proposed for regulation have always been below detection limits in EBMUD's source waters.

Trihalomethanes (THMs) are disinfection by-products and cancer causing compounds resulting from the disinfection of water with chlorine, which reacts with naturally occurring organic compounds to form THMs. The most significant known health risk in treated surface supplies is caused by THMs. The standard for THMs is currently 100 ug/L, but there is serious consideration within EPA to lower it to 10 to 50 ug/L. EBMUD's THMs are now about 25 ug/L.

List of Contaminants Regulated by the U.S. Government

Figure IV-6

List of Volatile Organic Chemicals (VOCs)

Trichloroethylene	Benzene
Tetrachloroethylene	Chlorobenzene
Carbon tetrachloride	Dichlorobenzene(s)
1,1,1-Trichloroethane	Trichlorobenzene(s)
1,2-Dichloroethane	1,1-Dichloroethylene
Vinyl chloride	cis-1,2-Dichloroethylene
Methylene chloride	trans-1,2-Dichloroethylene

Source: Fed. Reg. 47:43 (Mar. 4, 1982)

List of Other Contaminants Referenced by Amendments

Synthetic Organic Chemicals (SOCs)

Endrin*	Glyphosphate	Pentachlorophenol
Lindane*	Carbofuran	Pichloram
Methoxychlor*	1,1,2-Trichloroethane	Dinoseb
Toxaphene*	Vydate	Alachlor
2,4-D*	Simazine	1,2-Dibromomethane (EDB)
2,3,5-TP (Silvex)*	Polynuclear aromatic hydrocarbons (PAHs)	Epichlorohydrin
Total Trihalomethanes (TTHM)*	Polychlorinated biphenyls (PCBs)	Dibromomethane
Aldicarb	Atrazine	Toluene
Chlordane	Phthalates	Xylene
Dalapon	Acrylamide	Adipates
Diquat	1,2-Dibromo-3-chloropropane (DBCP)	Hexachlorocyclopentadiene
Endothall	1,2-Dichlorpropane	2,3,7,8-TCDD (Dioxin)

Inorganic Chemicals (IOCs)

Arsenic*	Silver*	Vanadium
Barium*	Fluoride*	Sodium
Cadmium*	Aluminum	Nickel
Chromium*	Antimony	Zinc
Lead*	Molybdenum	Thallium
Mercury*	Asbestos	Beryllium
Nitrate (as N)*	Sulfate	Cyanide
Selenium*	Copper	

Microbiological Contaminants

Turbidity*	Viruses	Filtration of surface water
Total Coliforms*	Standard plate count	Disinfection of all water
Giardia lamblia		

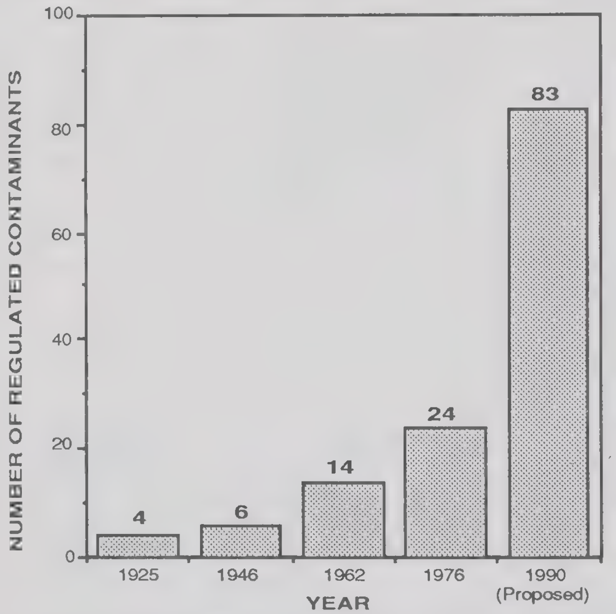
Radionuclides

Radium-226 and 228*	Beta particle and photon radioactivity*	Uranium
Gross alpha particle activity*		Radon

Source: Fed. Reg. 48:194 (Oct. 5, 1983)
*Already regulated

Number of Contaminants Regulated by the U.S. Government

Figure IV-7



Source: "Water Quality Considerations in Source Selection," by Okun, Harris & Tardiff

Trihalomethane Formation Potential (THMFP) is a scale established by laboratory tests under conditions similar to disinfection to measure the potential that a water source has for producing THMs. Studies have shown that the use of a water supply source lower in THMFP can be expected to result in lower THMs after treatment. As Figure IV-1 shows, THMFP in Pardee Reservoir is substantially lower than in Delta waters.

Total Organic Halogen (TOX) is a measure of the organic compounds associated with chlorine, bromine, and iodine, including trihalomethanes. Since most halogenated organics are suspected of being toxic or carcinogenic, the TOX in water is a useful indicator of toxic contaminants. TOX is low in Pardee Reservoir as can be seen in Figure IV-1.

Pesticides applied to agricultural lands can migrate into the surface water that drains the watershed. Currently only seven pesticides are regulated, and although water sample analyses have rarely revealed detectable levels of pesticides in the Delta, the high level of pesticide use in the Sacramento and San Joaquin River watersheds is sufficient to suggest that the Mokelumne and American Rivers represent lower health risk vis-a-vis pesticides. Pesticides have never been detected in Pardee Reservoir or the terminal reservoirs.

Inorganic Chemical Compounds consist primarily of heavy metals, such as lead and mercury, and minerals, such as nitrates or fluorides. The behavior and health effects of most inorganic compounds in water are well known and MCLs have been set by EPA. Some inorganic materials, such as selenium and fluoride, have desirable minimum as well as maximum values; the level of fluoride is, in fact, maintained between the minimum and maximum levels as part of the treatment process. The District's raw water sources meet the MCLs as shown in Figure IV-8. The major concern of inorganic compounds is their impact on the aesthetic qualities and customer costs, which are discussed later.

Sodium is an essential element in the human diet; however, evidence from epidemiologic, clinical, and animal studies suggests that chronic excessive sodium intake is associated with hypertension, defined as an increase in blood pressure. The American Heart Association (AHA) has advocated a sodium-restricted diet for the long-term management of hypertension and has suggested a maximum level of sodium in drinking water of 20 milligrams per liter (mg/L) (NRC 1980).

Figure IV-1 illustrates the low sodium levels in Mokelumne water compared with higher sodium levels in Delta sources. Historically, studies confirm that sodium levels in the Delta (Clifton Court and Indian Slough) are above the suggested maximum. In Mokelumne water, on the other hand, sodium levels are well below the recommended maximum.

Turbidity is an indication of the level of particulate matter suspended in water. High turbidity water is not only visually unacceptable to the consumer; it can shield microorganisms from the action of disinfectants. Furthermore, many inorganic and organic molecules associated with particulate matter in raw water demonstrate a capacity to react with and consume the chlorine or other disinfectant added to raw water (termed a disinfectant demand). Therefore, higher "demand" waters require greater dosages of chlorine in order to achieve adequate disinfection. These greater dosages of chlorine in turn increase the potential for THM formation.

The EPA has set an MCL for turbidity of 1 turbidity unit (NTU) to assure that the concentration of particulates in treated water is compatible with current disinfection techniques. Regulations proposed subsequent to the 1986 Safe Drinking Water Act Amendments would lower the MCL to 0.5 NTU or less at least 95 percent of the time. Figure IV-1 illustrates the low turbidity level in Pardee Reservoir before treatment.

Primary Drinking Water Standards (1986)

Figure IV-8

PRIMARY STANDARDS
Mandatory, Health-Related Standards Established by Environmental Protection Agency

PARAMETER	UNIT	MAXIMUM CONTAMINANT LEVEL (MCL)	EBMUD LEVEL*	
			RANGE	AVERAGE
CLARITY				
Turbidity	NTU	0.5 — 1	0.05 — 0.20	0.10
MICROBIOLOGICAL				
Total Coliform Bacteria per 100 mL		1	0 — 0.19	0.02
ORGANIC CHEMICALS				
Total Trihalomethanes (TTHM)	ppb	100	6—44	25
Pesticides	ppb	0.2 — 100	ND	ND
INORGANIC CHEMICALS				
HEAVY METALS				
Arsenic	ppb	50	ND — 10	ND
Barium	ppb	1000	7 — 73	15
Cadmium	ppb	10	ND — 1	0.16
Chromium	ppb	50	ND — 5	1.6
Lead	ppb	50	ND — 10	3.6
Mercury	ppb	2	ND — 0.30	ND
Selenium	ppb	10	ND — 7	ND
Silver	ppb	50	ND — 3	1.1
MINERALS				
Fluoride	ppm	1.4 — 2.4	0.7 — 1.0	0.85
Nitrate (as NO_3)	ppm	45	ND — 3	0.10
RADIONUCLIDES				
Gross Alpha (including Radium-226 and 228)	pCi/L	15	ND — 0.3	0.1
Tritium	pCi/L	20,000	ND	ND
Strontium-90	pCi/L	8	ND	ND
Gross Beta	pCi/L	50	ND — 2.2	1.3

Abbreviations and Units

NTU = Turbidity unit
ND = Not detected
ppm = parts per million (milligrams per liter)
ppb = parts per billion (micrograms per liter)
pCi/L = picocuries per liter

*Ranges were determined over an 8 year period (1980-87) except TTHM (1987), Radionuclides (1983) and Turbidity (1987).

AESTHETIC QUALITY

The aesthetic quality of drinking water is one of the most important indicators of its acceptability to consumers. Secondary Drinking Water Standards were established to regulate certain characteristics and chemical constituents of drinking water which may be aesthetically objectionable but which are not hazardous to health at levels found in drinking water (Department of Health, 1977). These standards require utilities to protect the public welfare by assuring a supply of pure, wholesome and potable water. A list of the constituents regulated by these standards and the levels of these constituents in EBMUD water are given in Figure IV-9.

Pardee Reservoir provides consistently good tasting water because it is very low in minerals, is not

Secondary Drinking Water Standards (1986)

Figure IV-9

SECONDARY STANDARDS (1986) Aesthetic Standards Established by California Department of Health Services				
PARAMETER	UNIT	MAXIMUM CONTAMINANT LEVEL (MCL)	EBMUD LEVEL*	
			RANGE	AVERAGE
PHYSICAL PARAMETERS				
Color	units	15	2—12	4
Odor—Threshold	units	3	ND—9	Less than 1
CHEMICAL PARAMETERS				
Copper	ppm	1	ND—0.021	0.006
Corrosivity	MPY	Relatively low (<10)	1—7	3
Iron	ppm	0.3	ND—0.100	0.05
Manganese	ppm	0.05	ND—0.032	0.003
Foaming Agents (MBAS)	ppm	0.5	ND—0.03	0.02
Zinc	ppm	5.0	ND—0.060	0.013
Chloride	ppm	250	2—25	3
Sulfate	ppm	250	1.1—60.5	5.6
MINERALS				
Total Dissolved Solids (TDS) or	ppm	500	37—245	49
Specific Conductance	µmho/cm	900	41—411	70

Abbreviations and Units

ppm = part per million (milligrams per liter)
MPY = mils per year
µmho/cm = micromho per centimeter
ND = Not detected

*Averages were determined over a 6-year period (1980—85)

plagued with algal blooms, and requires very little chlorine for disinfection. Briones Reservoir provides good tasting water because the runoff from its protected watershed results in minimal algal blooms and the depth of the reservoir allows careful selection of water at various elevations in the reservoir. However, San Pablo and Upper San Leandro Reservoirs are routinely affected by taste and odors as previously described. The best defense against taste and odor problems is a high quality source water with multiple treatment steps for taste and odor control.

Figure IV-1 shows the high quality of Pardee Reservoir and the American River relative to the Delta with respect to average mineral (chloride and total dissolved solids) and taste and odor levels. While the levels of the constituents are relatively uniform in Pardee Reservoir and the American River, they are subject to wide variation in the Delta due to the variability of inflows to the Delta, particularly during dry years.

Customer Costs

In 1983, J. M. Montgomery Engineers conducted a water quality study for EBMUD which identified and quantified water quality related costs to consumers and industrial users. The following summarizes their findings. All costs are in 1983 dollars. Identifiable consumer costs affected by water quality can include purchase of bottled water, use of home softeners, higher consumption of soap and detergents, more frequent replacement of water heaters, and corroded household plumbing.

Consumer use of bottled water depends on public perception of water quality, including perceived taste, odor and mineralization. Use of bottled water can be estimated to a first approximation from mineral levels (TDS). On this basis, average annual costs per household would range from $12 for Pardee Reservoir water to $26 for Indian Slough water. The actual spread may be greater because other factors,

like odor, influence consumers to purchase bottled water also.

Estimates for consumer cost of home water softeners range from $0 per household per year for Pardee Reservoir water since softeners are not needed for Mokelumne water to $6 per household per year for Indian Slough water.

The estimated incremental annual cost per household (compared to the current Pardee Reservoir supply) for soap and detergent purchase, bottled water use, and home softeners would range from approximately $2 with American River water to $31 with Indian Slough water.

Other water-quality related consumer costs, especially replacement of household plumbing, may be significant. For categories of consumer costs, such as the use of at-the-tap purification units, insufficient data are available to estimate costs, although they are probably significant.

Identifiable water quality-related incremental costs to industrial users include chemical costs of demineralization, softening, and operation of cooling towers and boilers. Industrial users would be adversely affected by rapid changes in delivered water quality (which occurs in Delta water). Capital costs of industrial water treatment facilities are based on the highest level of mineralization (total dissolved solids) to be experienced. Use of 100 percent Delta water would require considerable capital investment by industry.

CONCLUSIONS REGARDING SOURCE

The final quality of the water delivered to the consumer depends on two factors: the quality of the source water and the effectiveness of treatment. Figure IV-10 compares water quality control strategies relative to several water quality issues.

The sources available to the District are its Mokelumne River supply and the Delta in the near term plus the American River in the future. The District's water quality monitoring program, summarized in Figure IV-1, shows that the American River is the source most similar to the Mokelumne River and that Delta sources have the lowest water quality.

If Delta water were planned to be used as a supplemental or an emergency source, significant water treatment improvements in addition to those already planned would be required. All of the District's treatment plants, particularly the direct filtration plants, would have to be modified. Sedimentation facilities at the direct filtration plants and the addition of ozone and GAC facilities (larger than now under construction at Sobrante and Upper San Leandro Filter Plants) at all of the plants would be required. This is not likely to be feasible due to site constraints at the existing plants. The alternative would be to construct one treatment plant with all of the processes near the Delta. Its treated water would be injected into the Mokelumne Aqueducts. The cost for such a plant which would reduce the THMFP of Delta water to that of Mokelumne water would be approximately $370 million for 170 MGD capacity.

Beyond the treatment cost differences among the sites, a greater, non-monetary difference exists: risk to public health. The Mokelumne and American river watersheds are protected from a multitude of natural hazards such as organic compounds (e.g., pesticides, urban storm runoff, chemical spills). The greater the hazard to the watershed, the greater the risk to public health, even with the best treatment available.

In addition to the increased health risk posed by the multitude of unidentified compounds in sources such as Delta water, certain health aspects as well as the aesthetic qualities of the chosen source water must be carefully considered. The average sodium levels in the Delta, for instance, are far above that recommended for people with hypertension. The seasonal high levels of chloride also pose a significant aesthetic problem (salty taste). It must also be realized that a supplemental source would be used during a drought or in case of emergency, and the quality during that period may be negatively impacted. In the case of the Delta, the reduction in fresh water flows caused by a drought or the increase in salt water flows caused by failure of islands during an earthquake would seriously degrade the quality of Delta water as previously described.

The public has indicated repeatedly in recent years that they are not willing to accept any risk from its drinking water and that they are willing to pay to improve water quality. This attitude is exemplified by the passage of measures such as Proposition 65 and the high usage of bottled water statewide. Proposition 65 makes it illegal to discharge any substance known to cause cancer or birth defects into a drinking water source.

It can be concluded then that EBMUD's present policy of seeking sources of the highest quality for both normal use and use during emergencies should continue, and EBMUD should use Sierra sources only and avoid the use of Delta water. EBMUD should continue to pursue the use of advanced treatment technology to assure compliance with future drinking water regulations and to minimize the amount of chemicals required for water treatment.

Comparison of Water Quality Control Strategies

Figure IV-10

WATER QUALITY ISSUES	WATER QUALITY CONTROL STRATEGY			CONCLUSIONS
	NO PROJECT	USE HIGH QUALITY/PROTECTED SOURCES	IMPROVE TREATMENT	
THMs	Probably will be unable to meet Disinfection Byproducts Rule.	Sources with low THMFP will be treatable with lower cost and/or to lower THM levels.	Probably will need some capital improvements; cost varies greatly with source water.	Use sources low in THMFP, improve treatment as required.
Taste & Odor	T&O will continue to be a seasonal problem with terminal reservoirs and when Delta is used as an emergency source.	T&O will continue to pose few or no problems for Sierra sources.	T&O in terminal reservoirs can be greatly reduced with GAC and ozone, but probably not eliminated.	Improve treatment; however, no amount of treatment can totally eliminate effect of source.
Excessive Salinity	Severe problem during extended outages of the Mokelumne Aqueduct when Delta is used as an emergency source.	Salinity is not a problem for any source except the Delta.	Tremendous cost associated with salinity removal.	Avoid Delta as a source.
Pesticides	Only a threat for relatively unprotected sources, e.g. Delta.	Protected sources with limited pesticide use in their watershed are the only sure method of avoiding health threats.	Can be treated, but "safe" levels not been defined and measurement is difficult.	Use protected sources, i.e., those not exposed to agriculture.
Chemical Contamination	Unprotected sources will continue to be subject to tanker truck spills, urban runoff, etc.	Protected sources offer the only protection from spills and urban development.	Impossible to treat gross contamination which could result from spill.	Use protected sources, i.e., those not exposed to development, urban runoff or heavy traffic.
Future Regulations	Likely that standards will be violated.	Many regulations will already be met for protected sources; any needed improvements will be relatively minor.	Treatment improvements will continuously be under construction, at great cost. No guarantee that all future regulations can be met with treatment alone.	Use protected source in order to allow maximum flexibility and improve treatment as required.
Unknown Organics	Human health effects unknown; assumed to be adverse.	The safest, surest method.	May or may not remove "enough" of the organics.	Use protected source to afford protection against unidentified contaminants.

NEEDED IMPROVEMENTS

Watershed Management and Improvement

EBMUD owns 26,000 thousand acres of watershed land in the East Bay area. Of this, 8,000 acres is in water surface. In addition the East Bay Regional Park District and other public agencies own approximately 20,000 acres of open space contiguous to EBMUD's watershed lands. This is a permanent public asset which involves 80 miles of interconnected trails. Extensive treatment is provided for the water from San Pablo and Upper San Leandro Reservoirs which contain drainage from the Cities of Orinda and Moraga. The Briones Reservoir watershed is almost entirely in public ownership and the alternative terminal reservoir projects can be largely protected by public ownership.

Watershed management is essential to providing high quality water to prevent sewage or other pollutants from entering reservoirs. This is threatened whenever development is proposed on adjacent watershed lands. EBMUD's ongoing watershed reconnaissance, water quality monitoring and land management activities will continue.

Watershed management would be improved by EBMUD's purchase of watershed lands currently in other ownership and which may have a potential for development. Acquisition of the land to the ridgelines around the terminal reservoirs to the extent possible would help assure that the high quality of stored water can be maintained into the future. The potential watershed land acquisitions under consideration are shown in Figures IV-11, IV-12 and IV-13. More detailed descriptions of these properties can be found in Appendix C.

The San Pablo watershed could benefit by acquisition of a total of 249 acres at an estimated cost of $1.9 million. The entire Briones watershed could be placed into public ownership with the purchase of 723 acres at an estimated cost of $4.8 million. The Upper San Leandro watershed could benefit by acquisition of 498 acres at an estimated cost of $3.0 million plus the acquisition of the Buckhorn Reservoir watershed. The watershed around the Buckhorn Reservoir site could be entirely owned with the purchase of approximately 678 acres at an estimated cost of $2.5 million. The watershed around the Pinole Reservoir site would involve purchase of 24 parcels totaling 2,687 acres at an estimated cost of $16.1 million.

These acquisitions would also minimize ridgeline development in the Moraga/Orinda area and provide opportunities for significant trail enhancement.

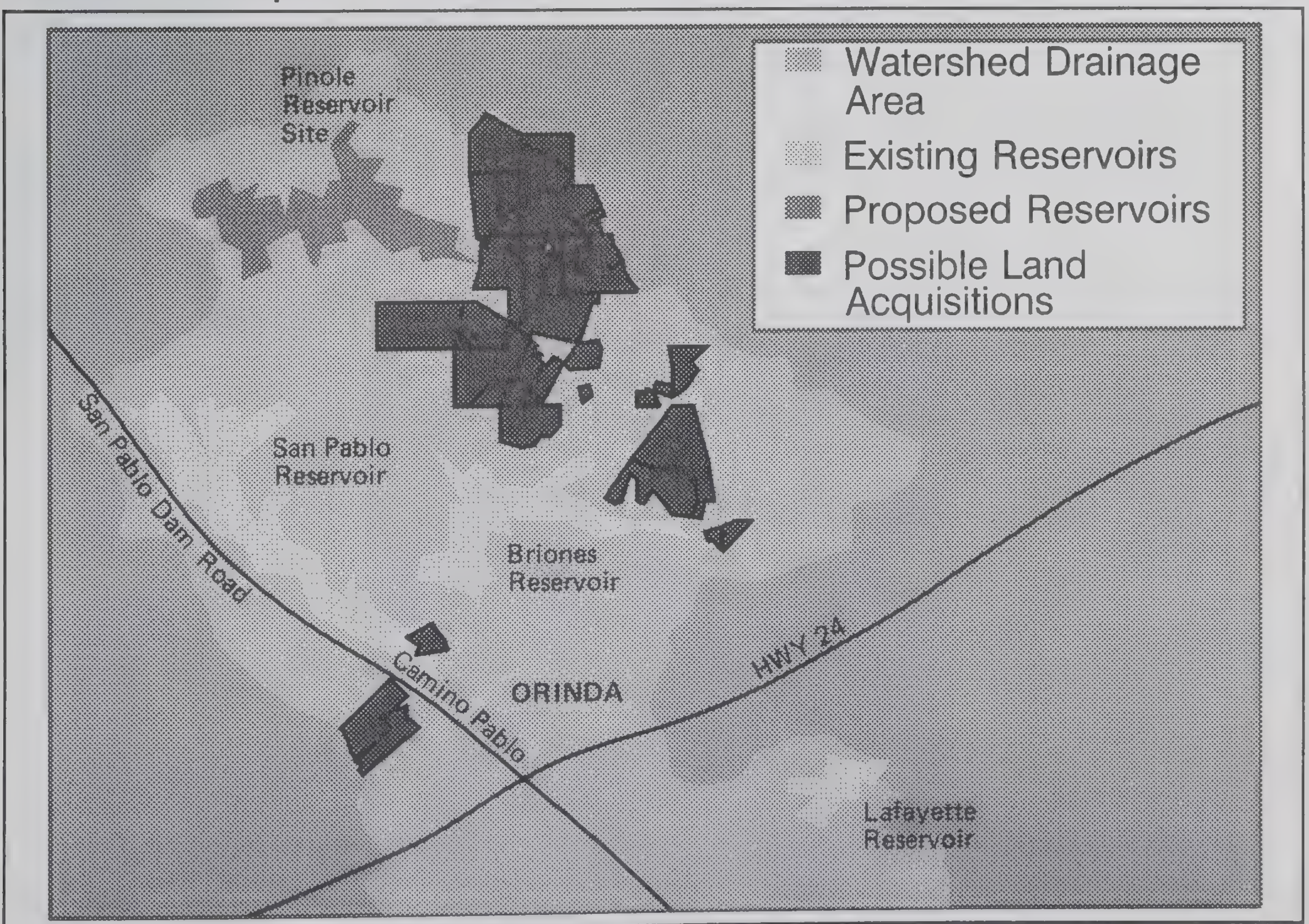
Treatment Improvements

Although EBMUD treated water is superior to state and federal standards, EBMUD continues to (1) modernize its treatment plants which range in age from 21 to 67 years, (2) improve its taste and odor control capabilities, (3) pursue advanced treatment technologies in anticipation of future drinking water regulations, and (4) evaluate future technologies. EBMUD is currently undertaking approximately $35 million in improvements as part of its ongoing treatment improvement program which is summarized in Figure IV-14.

EBMUD Watershed Improvements

Possible Land Acquisitions — North

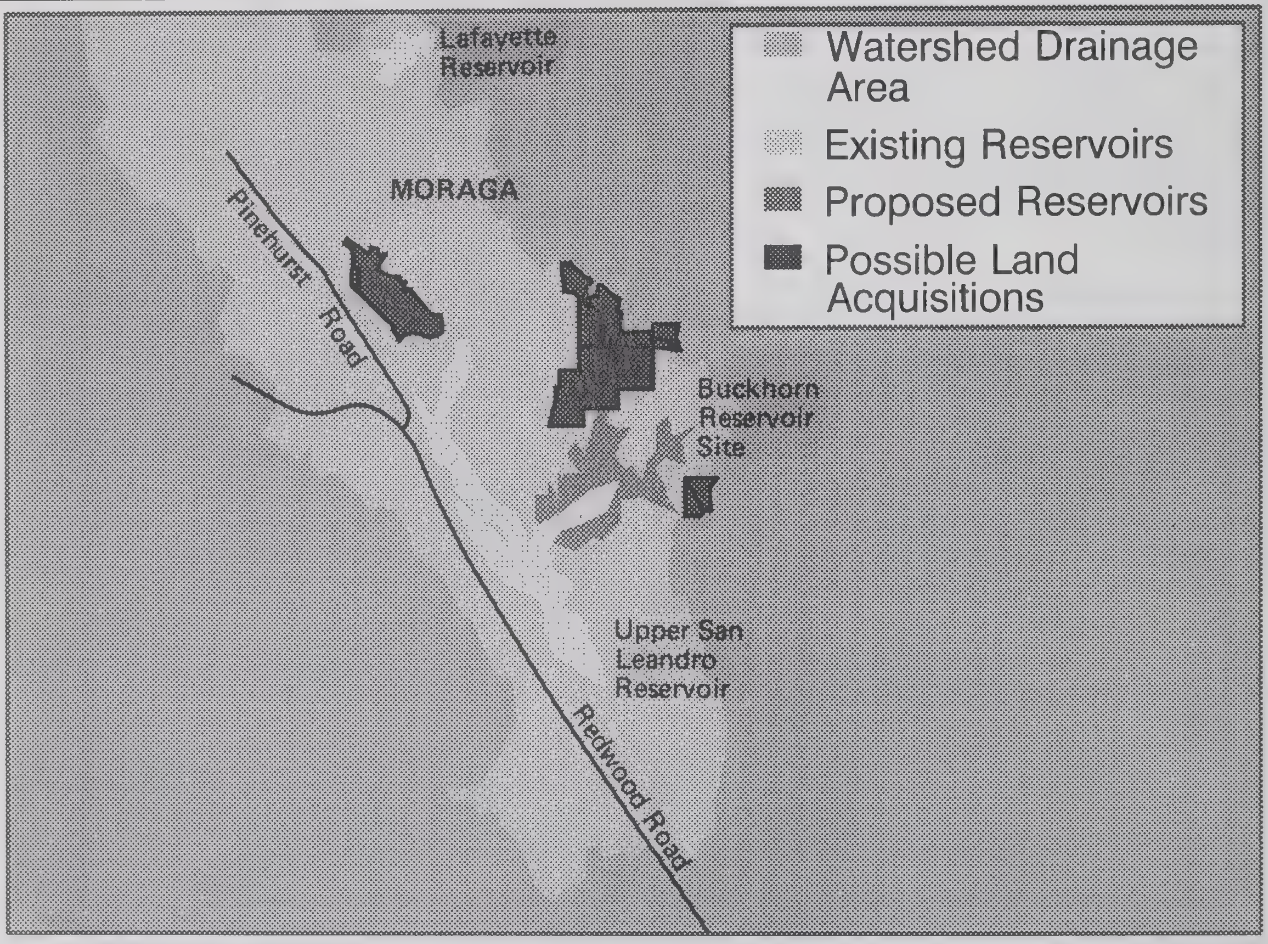
Figure IV-11



EBMUD Watershed Improvements

Possible Land Acquisitions — South

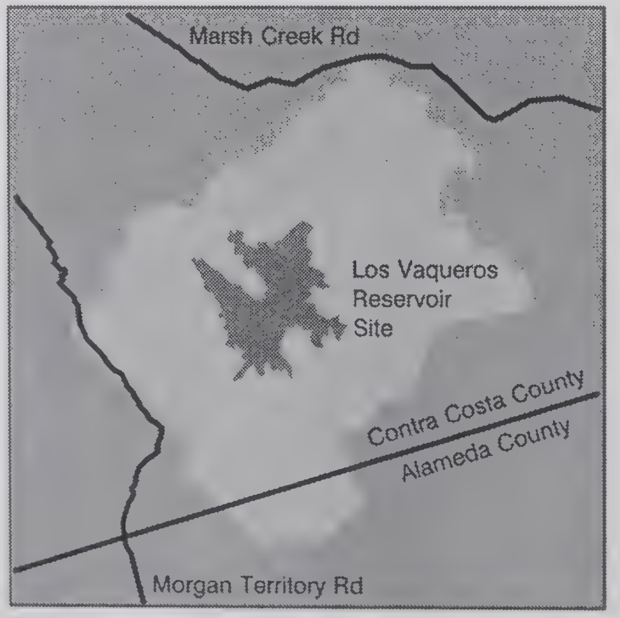
Figure IV-12



EBMUD Watershed Improvements

Possible Land Acquisitions — East

Figure IV-13



Treatment Improvement Program

Figure IV-14

PROBLEM	SOLUTION
TREATMENT PLANT MODERNIZATION — $18 MILLION	
Chemical Storage and Feed Control Improvements	
The plants need improved storage of chemicals both in terms of quantity and adequacy of environment. The existing devices for chemical feed are outdated and manually controlled.	Improve existing chemical storage facilities for chlorine, sulfur dioxide, caustic soda, polymer and lime. Installation of raw water flow meters at Orinda and Lafayette. Install chemical feed pumps that can be adjusted by a remote electronic signal. Install feed control equipment that will maintain chemical dosages as plant flowrates change.
Water Quality Monitoring Improvements	
On-line water quality monitors are outdated and limited in number.	Install turbidimeters for raw water and filtered water for all plants and all individual filters; pH meters on raw, filtered, and settled waters for all plants; and chlorine residual monitors for raw and treated water at all plants.
Filter Operation Improvements	
Filter operations are manually controlled and labor intensive.	Convert all existing pneumatic filter controls to electronic controls, replace all filter consoles and install programmable logic controllers to sequence backwash operations.
Solids Disposal Improvements	
Sedimentation basins require shutdown and draining for periodic cleaning. Plant capacity is thus reduced during this time. Solids accumulations can cause or contribute to taste and odor problems in the treated water.	Install continuous solids removal systems in the sedimentation basins of the full treatment plants and inmprove the existing solids disposal facilities at Lafayette, Orinda and Walnut Creek Filter Plants.
General Plant Improvements	
Emergency electrical supplies need expanded capacities to meet current plant operation requirements during power failures.	Install larger emergency generators, improve electrical equipment and make general improvements to the plant grounds.
TASTE AND ODOR CONTROL: GAC AND OZONE — $17 MILLION	
Seasonal algal blooms in the terminal reservoirs cause taste and odor at Sobrante and Upper San Leandro Filter Plants.	Install Granular Activated Carbon (GAC) to replace the existing sand filter media, and design and construct ozonation facilities at Sobrante and Upper San Leandro Filter Plants.
COMPLIANCE WITH FUTURE REGULATIONS: OZONE	
Improved methods in disinfection are likely to be required by impending drinking water regulations. Future regulations are likely to require the use of advanced treatment technology.	Perform pilot testing and preliminary design of ozonation facilities for Lafayette, Orinda and Walnut Creek Filter Plants.
FUTURE TECHNOLOGY: MEMBRANE FILTRATION	
An improved product with reduced chemical usage is a treatment objective.	Investigate the feasibility of the use of membrane filtration as a replacement for conventional treatment.

TREATMENT PLANT MODERNIZATION

Treatment plant modernization projects totalling approximately $18 million in improvements are now under design or construction.

These consist of upgrading chemical storage and feed systems to allow flow-pacing or residual feedback control of chemical feed. Also included are replacement of filter media, conversion of filter controls to provide automatic backwash sequencing, backwash water and solids handling facilities, and a system to allow computer control of plant processes. These improvements will be done at five of the six treatment plants (the sixth operates only during peak demand periods) and are scheduled for completion by 1994.

All of the improvements are designed to work well with the District's OP/NET system (a computer-based control system currently under construction for the water supply and distribution system). When completed, the improvements will result in higher water quality, lower chemical costs, less manual labor, less wastewater and lower solids handling costs.

TASTE AND ODOR CONTROL: GAC AND OZONE

Replacement of the coal and sand filter media at the Sobrante and Upper San Leandro Filter Plants with granular activated carbon at a cost of approximately $2 million has started. To complement the granular activated carbon in the removal of taste and odors, pilot testing and design of ozone generation and feed facilities for the Sobrante and Upper San Leandro Filter Plants will start in 1988. A preliminary estimate of the cost of these ozonation facilities is $15 million. Ozonation facilities for Sobrante and Upper San Leandro Filter Plants are scheduled to be completed in 1990.

COMPLIANCE WITH FUTURE REGULATIONS: OZONE

A proposed EPA rule on surface water treatment (SWTR) would require significant changes to EBMUD's water treatment processes, requiring the use of ozone instead of chlorine as the principal disinfectant. Pilot testing and preliminary design of ozone facilities for the Lafayette, Orinda, and Walnut Creek Filter Plants will start in 1988, which will determine the cost of retrofitting the filter plants.

Another important proposed rule is the Disinfection By-products Rule, which may reduce the MCL for THMs to as low as 10 ug/L. With the District's current method of disinfection, THMs cannot be reduced below 25 ug/L year-round.

The Disinfection By-products Rule will come into effect after the compliance date for the SWTR, meaning that important treatment improvement decisions regarding disinfection will already have been made. EPA has indicated that the only appropriate response by water utilities is careful, complete planning and reliance on generic, broad-spectrum treatment methods that will handle whole families of contaminants. System planning must take into account not only those regulations in effect, but all contaminants that will be regulated. Only the use of advanced treatment technology combined with highest quality sources will assure compliance with future drinking water regulations.

FUTURE TECHNOLOGY: MEMBRANE FILTRATION

An extensive alternative treatment technologies evaluation is underway at EBMUD, designed to decrease chemical use while producing a higher quality product. One technology being considered is membrane filtration, which is thought to remove turbidity, bacteria, Giardia, and other particulates without the addition of coagulants. Reducing the use of chemicals is consistent with EBMUD's objective of keeping to a minimum the amount of chemicals introduced into the water treatment process.

Chapter V
Selection of Proposed Program

OBJECTIVES

EBMUD's water supply problems and needs focus on three basic issues--security, shortage, and safety and health. These issues establish the objectives for development of the Water Supply Management Program:

- SECURITY: Provide security of the water supply against delivery system outages caused by floods and earthquakes.
- SHORTAGE: Provide an adequate water supply to meet dry year demands with limited water use restrictions.
- SAFETY AND HEALTH: Maintain high quality water.

Continuing from the problems and alternative solutions described in Chapters II, III, and IV, this chapter:

- Summarizes the alternatives for security, shortage, and safety and health and analyzes them as solutions for meeting the specific needs for improvement of the water supply system, to focus on the more-feasible alternatives;
- Evaluates the more-feasible alternatives in terms of a comprehensive program to meet water supply needs to the year 2020;
- Discusses the compatibility of the program alternatives with future decisions and the probable needs beyond 2020;
- Evaluates specific project site alternatives for implementing the program alternatives;
- Discusses the allocation of costs and financing; and
- Describes the proposed Water Supply Management Program.

ANALYSIS OF SECURITY ALTERNATIVES

Need for Improvements

The three Mokelumne Aqueduct pipelines cross the islands of the Sacramento-San Joaquin Delta for a distance of 16 miles, with 11 miles of the pipelines elevated above ground on pile supports and underwater crossings at three rivers. As described in Chapter II, these pipelines are vulnerable to severe damage and collapse due to major earthquakes and flooding. The potential outage of the Mokelumne supply for repair and reconstruction of the pipelines is 17 months in the event of a maximum earthquake on the Antioch fault in the western Delta. The more likely event (estimated frequency of once in 83 years) is an earthquake on one of 12 faults within 50 miles of the Delta with an outage of 13 months, which is assumed as a basis for planning purposes. The standby storage in EBMUD's five terminal reservoirs in the East Bay area is equal to only four to six months of water demand, which means that a severe rationing program to reduce demand by 70 percent would be required to survive a 13-month outage.

The security of the Mokelumne supply needs to be improved to:

- Assure that an adequate high quality supply is available to meet water demand, with rationing, during an extended outage; and

- Limit the severity of rationing during an extended outage.

The various alternatives considered in Chapter II for improving the security of the water supply system are given in Figure V-1.

Do Nothing

To do nothing would mean a continuation of the problem with the need for severe water rationing during an extended outage. In the event of a disaster, EBMUD would not be prepared to minimize the adverse impact on EBMUD customers. Deterioration of the conditions in the Delta, particularly the levees, would over time mean increased vulnerability to damage and collapse of the pipelines with a worsening of the potential impact on EBMUD customers.

Water Conservation

EBMUD's water conservation efforts began in the early 1970's and have continued with an increased emphasis in recent years. Rationing in 1977 provided first hand experience with customer reaction to a short-term water shortage emergency and the impacts of water use restrictions. It is reasonable to assume that an acceptable level of short-term water conservation through rationing would be required in the event of a disaster, and should be part of EBMUD's water supply planning.

The alternative of expanding EBMUD's water conservation program to keep water demand during normal conditions at a low enough level to survive an extended outage of the Mokelumne supply would have to be based on extreme mandatory measures.

Alternatives for Improving Security

Figure V-1

ALTERNATIVE	REMARKS
1. DO NOTHING	Continue risk of extended water system outage due to flooding or earthquake damage to aqueduct pipelines in the Delta, with need for severe water rationing during the outage.
2. WATER CONSERVATION (Additional Measures)	Continue existing program and implement additional feasible measures which would save a total of 7 MGD by 2020 ($0.6 million per year); this would not provide security against an extended outage.
3. WATER RECLAMATION (Additional Projects)	Continue existing program and implement additional feasible projects which would save about 5 MGD by 2020 ($15 million); this would not provide security against an extended outage.
4. LEVEE AND FOUNDATION IMPROVEMENTS IN THE DELTA	Continue levee maintenance; upgrade levees; investigate possible levee reinforcement and improvement of pipe supports; and do testing and preliminary engineering for potential future pipeline replacement ($10 million); this would reduce some risks of outage but would not solve the security problem.
5. NEW AQUEDUCT PIPELINE ACROSS THE DELTA	Pipeline designed to withstand maximum earthquake would provide security against an extended outage ($265 million); field testing of pipeline support designs and studies of levee reinforcement are needed; future implementation of the USBR contract could affect the size of the pipeline.
6. WATER BANKING (Additional Terminal Storage)	Additional storage of 145,000 acre-feet would provide security against a 13-month outage with rationing limited to a 25% reduction of demand during the outage, at a projected demand of 270 MGD in the year 2020 ($152 to $186 million).
7. INTERTIES WITH OTHER AGENCIES	No water agency has significant long-term surplus water that EBMUD could depend on for security against an extended outage; increase in capacity of existing connections with San Francisco's Hetch Hetchy system through Hayward should be studied.
8. DELTA WATER USE	Flooding due to levee failure or earthquake would cause salt water intrusion into the Delta with extremely high levels of salinity making the water unusable, with no Mokelumne water for blending.
9. GROUNDWATER RESOURCES	Usable groundwater resources within EBMUD are 1 to 2 MGD, which is inadequate for security.

Demand is currently about 220 MGD and is projected to increase to 270 MGD in 2020 (see following section on shortage). The existing standby storage in the terminal reservoirs will accommodate a demand of only 81 MGD for 13 months, which would require reductions of 139 MGD today and 189 MGD in 2020.

In Chapter III it was shown that continued implementation of the existing water conservation program would achieve a reduction of 4 MGD in 2020. Additional measures considered to be the most reasonable, feasible, and publicly acceptable would achieve an additional 3 MGD savings, for a total reduction of 7 MGD. Theoretical measures would have a potential for saving an additional 17 MGD by 2020 by getting into the realm of mandatory measures; however, these would be costly to customers and have unproven records. For example, mandatory replacement of toilets with ultra-low flush models by all residential customers could save about 13 MGD by 2020, but would cost several hundred dollars per home.

A permanent reduction of current demand to 81 MGD (63 percent reduction) would require extraordinary changes in water use by residential, industrial, commercial, institutional, and irrigation customers, with significant investment by customers in water saving equipment. There would be major impacts on the economy and lifestyle of the East Bay area. The experience with rationing during 1977 demonstrated what EBMUD customers had to do to achieve only a 39 percent reduction in demand—landscape irrigation was drastically reduced or eliminated, people flushed toilets and used showers less frequently, and non-essential water uses were suspended. Industrial and institutional customers became more efficient in their water use by installing new equipment, repairing leaks, and modifying processes, much of which continues today making further reductions in water use more difficult.

If the permanent reduction under normal conditions was less, for example a 35 percent reduction to a level of 143 MGD, the restrictions on water use would be similar to the rationing in 1977 but with long-term impacts on the economy and lifestyle. Then in the event of an extended outage, extreme measures would be necessary to further reduce demand to 81 MGD.

It is difficult to speculate on the reductions that would be assigned to the various categories of customers under such an approach. However, if the impact on the economy of the region were to be minimized then most of the burden for the 63 percent reduction would have to be borne by an even greater reduction in residential and irrigation water uses (together they account for about two-thirds of current demand).

As new development receives water service and demand increases, the extreme water conservation measures would have to become stricter to be able to survive a 13-month outage. The 63 percent would increase to a 70 percent reduction in 2020 to achieve a demand level of 81 MGD.

EBMUD's effort in 1987 to have customers voluntarily reduce demand by 12 percent during the last half of the year did not achieve that result, although it may have kept the demand from increasing more. Obviously, the intended results of a water conservation program are not always reliable and predictable. Public acceptance of the need to conserve and the conservation measures are important factors.

Water pricing has been investigated as a water conservation measure, but EBMUD experience and studies show that under normal water supply conditions it is not effective. For example, the 50 percent increase in water rates for water service to customers at higher elevations over the past five years has shown no reduction in water use. Furthermore, EBMUD is required by law to charge no more than the actual cost of providing water service. On the other hand, the 1977 experience with rationing showed that the threat of severe financial penalties for excessive use coupled with the declaration of an emergency can be effective on a short-term basis.

Water use efficiency through conservation is an important element of water supply management; however, it is not a viable alternative for security of the EBMUD water supply against extended outages because the demand reduction needed (63 to 70 percent) would require extraordinary changes in water use by EBMUD customers that would be expensive, would adversely impact the economy and lifestyle, and are unlikely to be accepted by the public.

Water Reclamation

The reuse of water through water reclamation is an option for non-potable water uses such as irrigation and industrial cooling. Feasible reclamation projects require a large non-potable demand in a limited area, close proximity to a wastewater source, and limited additional treatment requirements. In Chapter III it was shown that current reclamation projects save approximately 4.7 MGD, and additional projects would reduce demand by an additional 5 MGD. Future reclamation projects could provide some additional savings, but not in the range of the 139 to 189 MGD reduction necessary to be able to survive a

13-month outage of the Mokelumne supply (see water conservation discussion above). When water uses are transferred to reclaimed water as a source, then the burden of demand reduction during an outage has to shift to other customers.

Water reclamation, like water conservation, is an important element of water supply management because it increases the efficiency of water use; however, it cannot alone or in combination with water conservation be a viable alternative for security of the EBMUD water supply against extended outages.

Levee and Foundation Improvements in the Delta

As described in Chapter II, EBMUD participates in the maintenance, repair, and upgrading of levees to avoid deterioration of the conditions that could cause levee failure due to sloughing, erosion, or overtopping. From 1981 through 1987, EBMUD contributed $1.3 million to this reclamation district work, and its contribution for completing it would be about $2.0 million. This would maintain the existing level of risk of failure. However, it would not provide physical protection against levee failure due to ground shaking caused by an earthquake and the potential for an extended outage of the water supply system, because of the poor foundation conditions—the peat and sandy soils on which the levees were built—and the poor quality of levee construction. It is estimated that an additional $6 million would be spent to further upgrade and improve the levees.

If the levees could be adequately reinforced, the foundation conditions under the levees and aqueduct pipelines adequately improved, and the pipeline supports and piles reconstructed to resist very high levels of ground shaking due to a major earthquake, then the risk of extended outage of the water supply system would be substantially reduced. However, this is not feasible because such levee reinforcement and foundation improvement technology is only conceptual and unpredictable, and the cost of reconstructing the pipeline supports and piles would exceed that of building a separate new pipeline across the Delta (next alternative below).

There is preliminary engineering work that can be done for future improvements in the Delta that would reduce some risks of water supply outage by being prepared for a disaster:

- Investigation and feasibility studies of levee reinforcement and of modification of supports under the existing aqueduct pipelines for reducing the risk of aqueduct damage due to flooding and lower levels of ground shaking caused by earthquakes; and
- Field testing and preliminary design of possible pile support systems and a future aqueduct pipeline across the Delta to shorten the response time in the event of a disaster.

The cost of the investigation and feasibility studies is estimated at $0.5 million and the field testing of possible support systems is estimated at $1.5 million. The cost of preliminary design of a new pipeline depends on effort required, which cannot be determined until after the investigation, testing, and studies.

Levee maintenance and repair and preliminary engineering for future improvements in the Delta would be an important element of water supply management, but is not a viable alternative for security of the EBMUD water supply against extended outages.

New Aqueduct Pipeline Across the Delta

Construction of a new pipeline or pipelines across or around the Delta could provide secure delivery of the Mokelumne supply. It would be designed to survive the estimated maximum ground shaking due to earthquake and long-term inundation if an island is flooded. Full capacity would require two 86-inch pipelines. Studies indicate that the most cost-effective alignment is parallel to the existing aqueducts.

The pipe supports under the elevated pipe would be designed to withstand the maximum expected earthquake forces and to accommodate the liquefiable sandy foundation soils. The design would also take into account the effects of scour around pipe supports from the flow through a levee break. Field testing of possible pipe support and pile system designs and investigation of levee reinforcement at river crossings would be required. The estimated total project cost for two pipelines is $265 million.

The implementation of EBMUD's contract with the U. S. Bureau of Reclamation for delivery of supplemental water from the Folsom South Canal could affect the size of the pipeline. Because of the high cost of this alternative, the possibility of a delivery capacity above 325 MGD should be considered. This might require delaying design and construction until the legal obstacles related to the USBR contract are cleared.

Water Banking--Additional Terminal Storage

In Chapter II it was shown that water banking can provide security against an extended outage of the Mokelumne supply. In this alternative, the standby capacity in EBMUD's five terminal reservoirs would be increased by the additional storage provided in a new terminal reservoir west of the Delta, in or near EBMUD's service area. The amount of storage needed depends on the extent of outage planned for, the level of normal demand, and the planned reduction in water use during the outage. As shown in Figure V-2, the more-likely 13-month outage would require 145,000 acre-feet of additional storage at the projected demand of 270 MGD in 2020 with a demand reduction of 25 percent by rationing during the outage. If the planned demand reduction is 39 percent (the reduction achieved by rationing in 1977), then 100,000 acre-feet of additional storage would be required.

Reservoir sites are available for the additional storage required and are discussed later in this chapter. The estimated cost of this alternative depends on the site and the size of the reservoir. The ranges of total project costs based on 270 MGD demand in 2020 are:

Demand Reduction During Outage	Additional Storage Required (acre-feet)	Range of Estimated Project Costs ($ million)
39%	100,000	122 to 150
25%	145,000	152 to 186

The operational cost of filling a new reservoir would range from $11 to $17 million, depending on the site and the size.

Interties with Other Agencies

Adjacent and nearby water supply systems of other agencies offer the possibility of emergency supplies during an extended outage of the Mokelumne system. No utility has a significant long-term surplus that EBMUD can depend on for the required water quantity and outage time. In addition, water rights and environmental issues associated with any change in source or place of use could be significant. Nevertheless, intertie possibilities need to be considered.

San Francisco's Hetch Hetchy system could help in the event of a disaster in the Delta since it is not dependent on physical conditions in the Delta. The connection could be through the City of Hayward, with which EBMUD has emergency connections, or by constructing a major transmission pipeline between the Mokelumne Aqueducts and the Hetch Hetchy Aqueducts, from Walnut Creek south to Sunol in the Livermore Valley (27 miles) or from the Brentwood area south to a point in the Central Valley (25 miles). The water quality would be equal to that of the Mokelumne. The existing Hayward connections can deliver only 5 to 10 MGD, whereas a major transmission pipeline could deliver a significant quantity of water. Such a pipeline would cost approximately $100 million. Any interties with the Hetch Hetchy system might help in the event of a Mokelumne supply outage, if the water were available; but this would be an uncertainty.

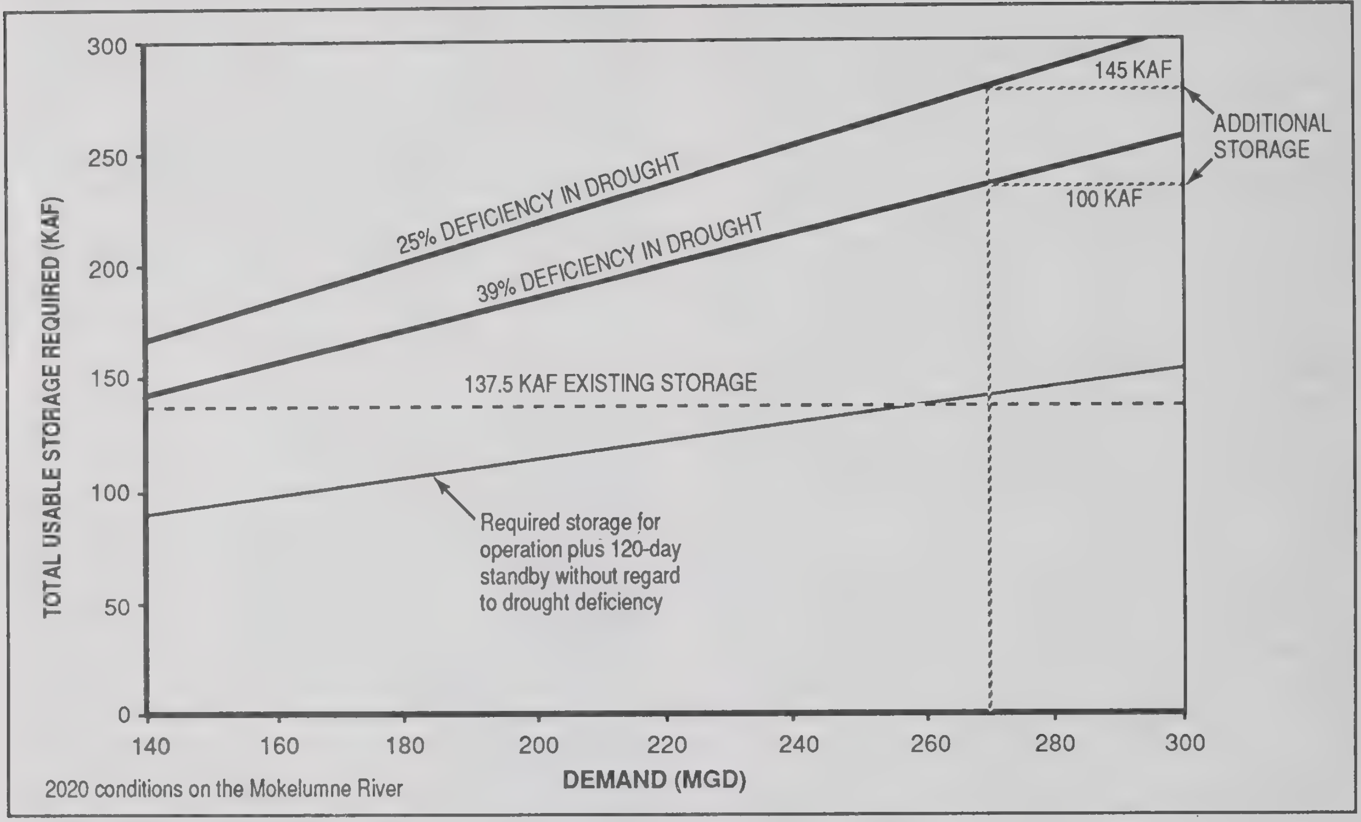
The Contra Costa Water District system is supplied from the Delta under a contract with the U. S. Bureau of Reclamation and its own water rights. The system has no appreciable storage, but CCWD is planning the construction of Los Vaqueros Reservoir. A supply from the Delta through CCWD is not a viable source that EBMUD could depend on because the flooding of islands resulting from a disaster in the Delta would cause salt water intrusion from the Bay with extremely high salinity levels. If use of Delta water were feasible, then EBMUD could pump directly from the Delta. (See discussion of Delta alternative below.)

The State Water Project pumps water from the southern Delta to Bethany Reservoir for the California Aqueduct and for the South Bay Aqueduct extending to southern Alameda County and Santa Clara County. As with the Hetch Hetchy source, a major transmission pipeline would be needed for a connection. It would have to be located between the EBMUD system and either Bethany Reservoir or the South Bay Aqueduct at a cost that may be on the order of $400 million for treatment facilities and a pipeline. The Delta diversion point would be further east than CCWD's, so the impact of salt water intrusion might be less depending on the type of disaster and the extent of flooding. Apart from the salinity problem, the quality of Delta water is inconsistent with the treatment systems at EBMUD's major filter plants and its water quality policy. As with the Hetch Hetchy source, a major transmission pipeline would be needed for connection. The State Water Project is not a source that EBMUD could depend on because of the uncertainty regarding salinity, the need for water treatment improvements, and the supply may not be available when needed.

Interties with other agencies are not a viable nor dependable alternative for solving EBMUD's security problem. However, they should be considered in EBMUD's water supply management. Studies can be undertaken to increase the capacity of the existing

Terminal Storage Needed for Security from 13-Month Aqueduct Outage

Figure V-2



connection with the Hetch Hetchy system through the City of Hayward and to further explore the feasibility of a direct intertie with the Hetch Hetchy system.

Delta Water Use

Water from the Delta is adequate in quantity, but its quality even under normal conditions is inconsistent with the treatment systems at EBMUD's major filter plants and its policy on water quality.

During the 1976-77 drought, EBMUD used Delta water mixed with existing supplies, with potentially adverse effects on the health of its customers. Significant taste and odor problems were experienced. The most serious concern was the increased level of trihalomethanes (THMs), which were caused in large part by elevated levels of bromide from sea water intrusion into the Delta. It took six years for the higher levels of THMs to be flushed out of EBMUD's terminal storage.

In the event of a Mokelumne supply outage caused by flooding or an earthquake disaster in the Delta, there would be no Mokelumne supply to blend with Delta water and EBMUD's major filter plants are not equipped to treat it. Furthermore, salt water intrusion from the Bay would cause extremely high levels of salinity which would make the water unusable.

Since its inception, EBMUD has maintained a policy of diverting no water from the Delta for delivery to customers (with the 1977 exception). EBMUD's Citizens Advisory Committee in 1985 recommended against such diversions, and state and federal policy urges providing water from the highest quality source. The use of Delta water is not a viable alternative for the needed security improvements.

Groundwater Resources

There are no groundwater resources of appreciable size located within EBMUD. The potential yield is about 1 to 2 MGD with very poor water quality.

Conclusions Regarding Security Alternatives

From the above analysis of security alternatives, the most feasible and cost-effective approach to solving the security problem is water banking with the construction of additional terminal storage. Also, it offers the possibility of being a multi-purpose solution (see next section on shortage). Capacity should be based on the more-likely 13-month outage and a

projected demand of 270 MGD in 2020, which is the mid-range growth rate and assumes full implementation of current water conservation and reclamation programs. A 25 percent demand reduction during outage should be part of the planning to reduce the severity of rationing and accommodate increased efficiency of water use. The amount of the additional terminal storage would be 145,000 acre-feet. The estimated cost would be $152 to $186 million, depending on the site selected (later in this chapter).

Construction of new aqueduct pipelines across the Delta, parallel to the existing aqueducts, could provide the needed security of the water supply system against outages. The estimated total project cost for pipelines to deliver the 325 MGD Mokelumne system capacity is $265 million, which is significantly more expensive than water banking. Field testing of design concepts for pipeline supports and levee reinforcement would be required prior to design and construction, and the results could increase the estimated cost. This would be a single purpose solution. Also, the desirable design capacity could be affected by future implementation of the American River supply under the USBR contract.

Water conservation cannot provide security without a permanent extraordinary reduction in demand by imposing extreme mandatory conservation measures, with significant impacts on the economy and lifestyle of the East Bay area. The cost of water banking would be about $10 per year per household; the cost of water demand reduction and the related lifestyle impacts would cost the customer that much or more.

The Delta could provide an adequate quantity of water, but its quality under normal conditions is inconsistent with EBMUD treatment systems and policy on water quality. In the event of a disaster in the Delta, salt water intrusion would cause extremely high levels of salinity to make the water unusable and there would be no Mokelumne water for blending.

Other options would not be solutions to the security problem, but would provide benefits and should be pursued as part of a balanced water supply management program: Additional water conservation measures and water reclamation projects to continue to improve water use efficiency; continue levee repair and maintenance to offset the deteriorating conditions in the Delta; perform technical studies (preliminary engineering) of levee and foundation improvements in the Delta to find ways of reducing the risks of outage; and conduct studies of intertie improvements with other agencies.

ANALYSIS OF SHORTAGE ALTERNATIVES

Need for Improvements

EBMUD has the water rights and system capacity to divert up to 325 MGD from the Mokelumne River and deliver it to its customers, a quantity that is available in most years. The exception is drought periods of two or more extremely dry years when the supply from the Mokelumne is substantially reduced. In a repeat of precipitation and runoff conditions like 1976-77, the Mokelumne supply in conjunction with existing storage would be only 215 MGD, which is the firm yield. The firm yield is projected to decline to 198 MGD by 2020 as higher priority water users upstream of Pardee Reservoir increase their diversions.

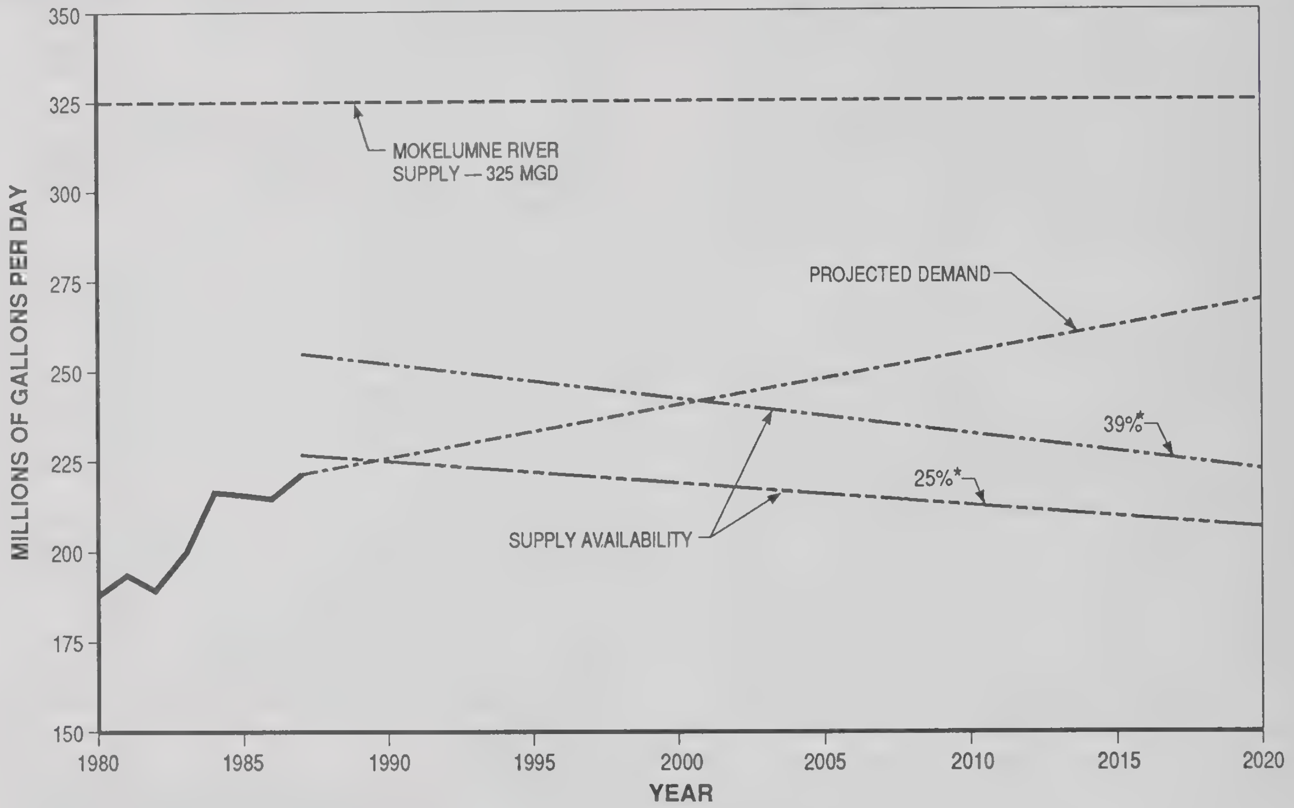
Chapter III shows that the current demand of about 220 MGD is projected to increase to a level between 251 and 280 MGD in 2020, depending on the actual rate of new development and the effectiveness of water conservation and reclamation programs. For planning purposes a projection of 270 MGD is being used, which assumes a mid-range growth rate and full implementation of the current and additional water conservation and reclamation programs. As a utility, EBMUD has an obligation to provide water service to new development planned and approved by the 20 cities and two counties within its boundary and to annexations within its ultimate boundary. Service beyond the ultimate boundary is not included in the projected demand except for the Crow Canyon Road Extension Corridor area, most of which was recently annexed to EBMUD.

The projections show that water demand will be greater than the supply available in a drought period like a repeat of 1976-77. The effect will be a water shortage beginning in the second year. The ability to meet demand during the second year is based on a balance between the amount of water available from the Mokelumne River and other sources, the extent to which demand is reduced by a rationing program, and the amount of terminal storage available.

EBMUD responded to this problem by adopting in 1985 a Water Supply Availability and Deficiency Policy that includes water use restrictions during drought periods as part of EBMUD's water supply planning, but limits rationing to the same 39 percent reduction in demand achieved in 1977. EBMUD's water supply system currently has the capacity to meet demand in a repeat of 1976-77 drought conditions with a 39 percent reduction in the second year, but only until demand in normal years reaches about 240 MGD around the year 2000, as shown in Figure V-3.

Supply Availability

Figure V-3



*Limit on rationing in second year of drought like 1976-77.

The 39 percent reduction in demand in 1977 had a significant impact on EBMUD customers--the loss in landscaping alone was estimated at $75 million ($ 1977). That demand reduction would cause greater hardship and cost to customers today because the efficiency of water use has improved, particularly by industrial and institutional customers. It is estimated that the 1977 rationing program would produce a 35 percent reduction today, and that percentage will decline further as water conservation continues to improve water use efficiency. Lowering the limit on rationing to a level such as 25 percent would reduce the severity and accommodate improved water use efficiency. However, the existing water supply system does not have the capacity to meet demand in a drought period with only a 25 percent reduction in demand.

EBMUD's water supply system needs to be improved to:

- Provide an adequate supply of high quality water, with rationing, during drought periods when there is a water shortage; and
- Reduce the severity of rationing during a water shortage.

The alternatives considered in Chapter III for solving the problem of water shortages are given in Figure V-4.

Do Nothing

To do nothing would mean a continuation of the problem of water shortages with an increasing severity of rationing as demand increases in the future. When demand exceeds about 240 MGD around the year 2000, the necessary percentage reduction in demand will be greater than the 39 percent achieved in 1977.

Water Conservation

As pointed out in the security section of this chapter, water conservation efforts began in the early 1970's and have continued with increased emphasis in recent years. Rationing in 1977 provided first hand experience with customer reaction to a short-term water shortage emergency and the impacts of water use restrictions. It is reasonable to assume that an acceptable level of short-term water conservation through water rationing would be required in the event of a water shortage, and should be part of EBMUD's water supply planning.

Alternatives to Reduce Water Shortages

Figure V-4

ALTERNATIVE	REMARKS
1. DO NOTHING	Continue the problem of water shortages during drought periods with increasing severity of rationing required in second dry year as demand increases in the future.
2. WATER CONSERVATION (Additional Measures)	Continue existing program and implement additional feasible measures which would save a total of 7 MGD by 2020 ($0.6 million per year); this would not be sufficient to solve the problem of shortages nor to reduce the severity of rationing.
3. WATER RECLAMATION (Additional Projects)	Continue existing program and implement additional feasible projects which would save about 5 MGD by 2020 ($15 million); this would not be sufficient to solve the problem of shortages nor to reduce the severity of rationing.
4. WATER BANKING (Additional Terminal Storage)	Additional storage of 95,000 acre-feet would provide capability of surviving a drought period with rationing limited to 25% during the second dry year, at a projected demand of 270 MGD in the year 2020 ($115 to $146 million).
5. USBR CONTRACT	Implementation of the USBR contract by connection to the Folsom South Canal would, in conjunction with storage, help reduce the severity of rationing in a drought; implementation is delayed by litigation, therefore this is not an available alternative.
6. INTERTIES WITH OTHER AGENCIES	No water agency has surplus water in a drought that EBMUD could depend on for shortages or reducing the severity of rationing, except those agencies with water supplies from the Delta; if use of Delta water is considered then EBMUD could pump directly from the Delta (see next alternative)
7. DELTA WATER USE	Water from the Delta is adequate in quantity, but its quality is inconsistent with EBMUD's treatment systems (improvements would cost $370 million) and its policy on water quality; water quality in the Delta is at its worst in dry years; experience shows that use of Delta water, even for short periods, should be avoided as a solution for the problem of shortages.
8. EXCHANGE WITH WOODBRIDGE DISTRICTS	Up to 39,000 acre-feet of additional Mokelumne water could be available if the Woodbridge districts were to reduce their Mokelumne diversions in exchange for some other source; one possible source could be the Delta (about $25 million for facilities) or a small amount from groundwater sources in the Woodbridge area; feasibility and institutional arrangements are uncertain; this water could help but would not solve the problem of shortages.

The alternative of expanding EBMUD's water conservation program to keep water demand down during normal conditions at a low enough level to survive a period of water supply shortage in a drought would require unusual mandatory measures. Demand is projected to increase from the current 220 MGD to 270 MGD in 2020 and the firm yield of the Mokelumne system (with no deficiencies during drought) is projected to decline from 215 MGD to 198 MGD at the same time. To keep demand from exceeding the firm yield would require permanent reductions of 5 MGD today, about 27 MGD (12 percent) in 2000, and 72 MGD (27 percent) in 2020.

In Chapter III and in the security discussion earlier in this chapter it was shown that continued implementation of the existing water conservation program and additional measures would achieve a reduction of 7 MGD by 2020. Theoretical measures would have the potential for saving an additional 17 MGD by 2020 by getting into the realm of mandatory requirements.

The permanent reductions necessary to keep demand from exceeding the firm yield would be greater than the potential 7 MGD or even an additional 17 MGD savings, and thus would require significant changes in water use by residential, industrial, commercial, institutional, and irrigation customers, with major investment by customers in water saving equipment and impacts on the economy and lifestyle of the East Bay area. Such permanent reductions in demand would make it very difficult to further reduce the demand in the event there are more than two extremely dry years in sequence during a drought. Because EBMUD's Mokelumne supply is more than adequate in most years, the benefits of such a strict full-time water conservation program would occur only in the occasional periods of shortage.

EBMUD's effort in 1987 to have customers voluntarily reduce demand by 12 percent during the last half of the year did not achieve that result, although it may have kept demand from increasing more. Obviously, the intended results of a water conservation program are not always reliable and predictable. Public acceptance of the need to conserve and the conservation measures are important factors.

As explained in the security discussion, EBMUD experience and studies show that water pricing is not effective as a means of reducing normal year demand. On the other hand, the 1977 experience with water rationing showed that the threat of severe financial penalties for excessive use coupled with the declaration of an emergency can be effective on a short-term basis.

Water use efficiency through conservation is an important element of water supply management; however, it is not a viable alternative for the solution to water shortages during periods of drought because the permanent demand reduction needed in normal years (27 percent reduction by 2020) would require significant mandatory changes in regular water use by EBMUD customers that would be expensive, would adversely impact the economy and lifestyle, and are unlikely to be accepted by the public.

Water Reclamation

As discussed in the security section earlier in this chapter, the potential for additional water reclamation projects is limited and would reduce demand by only 5 MGD. Water reclamation would not provide the reduction in normal demand of up to 72 MGD needed in 2020 to be able to survive a water shortage. Another consideration is that when water users are transferred to reclaimed water as a source, then the burden of demand reduction during a shortage has to shift to other customers.

Water reclamation, like conservation, is an important element of water supply management because it increases the efficiency of water use; however, it cannot alone or in combination with water conservation be a viable alternative for the solution to water shortages during periods of drought.

Water Banking—Additional Terminal Storage

In Chapter III it was shown that water banking can provide the adequate supply needed to survive a repeat of a drought like 1976-77 and to reduce the severity of rationing. In this alternative, the standby capacity in EBMUD's five terminal reservoirs would be increased by the additional storage provided in a new terminal reservoir. The amount of storage needed depends on the level of normal demand and the planned reduction in water use during the shortage. As shown in Figure V-5, a repeat of 1976-77 drought conditions would require 95,000 acre-feet of additional storage for the projected demand of 270 MGD in 2020 with a demand reduction of 25 percent during the second year. If the planned reduction is 39 percent (the reduction achieved by rationing in 1977), then 55,000 acre-feet of additional storage would be required.

Reservoir sites are available for the additional storage required and are discussed later in this chapter. The estimated cost of this alternative depends on the site and size of the reservoir. The ranges of total project costs are:

Demand Reduction During Outage	Additional Storage Required (acre-feet)	Range of Estimated Project Costs ($ million)
39%	55,000	86 to 112
25%	95,000	115 to 146

The operational cost of filling a new reservoir would range from $6 to $11 million, depending on the site and size.

USBR Contract

The use of water under EBMUD's 1970 contract with the U. S. Bureau of Reclamation for 134 MGD of American River water via the Folsom South Canal would increase the supply to EBMUD customers in normal years and could help reduce the severity of rationing in a drought. In the current litigation over the contract, EBMUD has proposed to avoid diversions when minimum flow standards are not met in dry years in the lower American River. This could result in EBMUD not taking delivery of water in a drought year like 1977. To deliver the water, facilities would have to be constructed from the Folsom South Canal to the Mokelumne Aqueducts. Implementation is currently delayed by the litigation and therefore the USBR contract is not considered an alternative at this time.

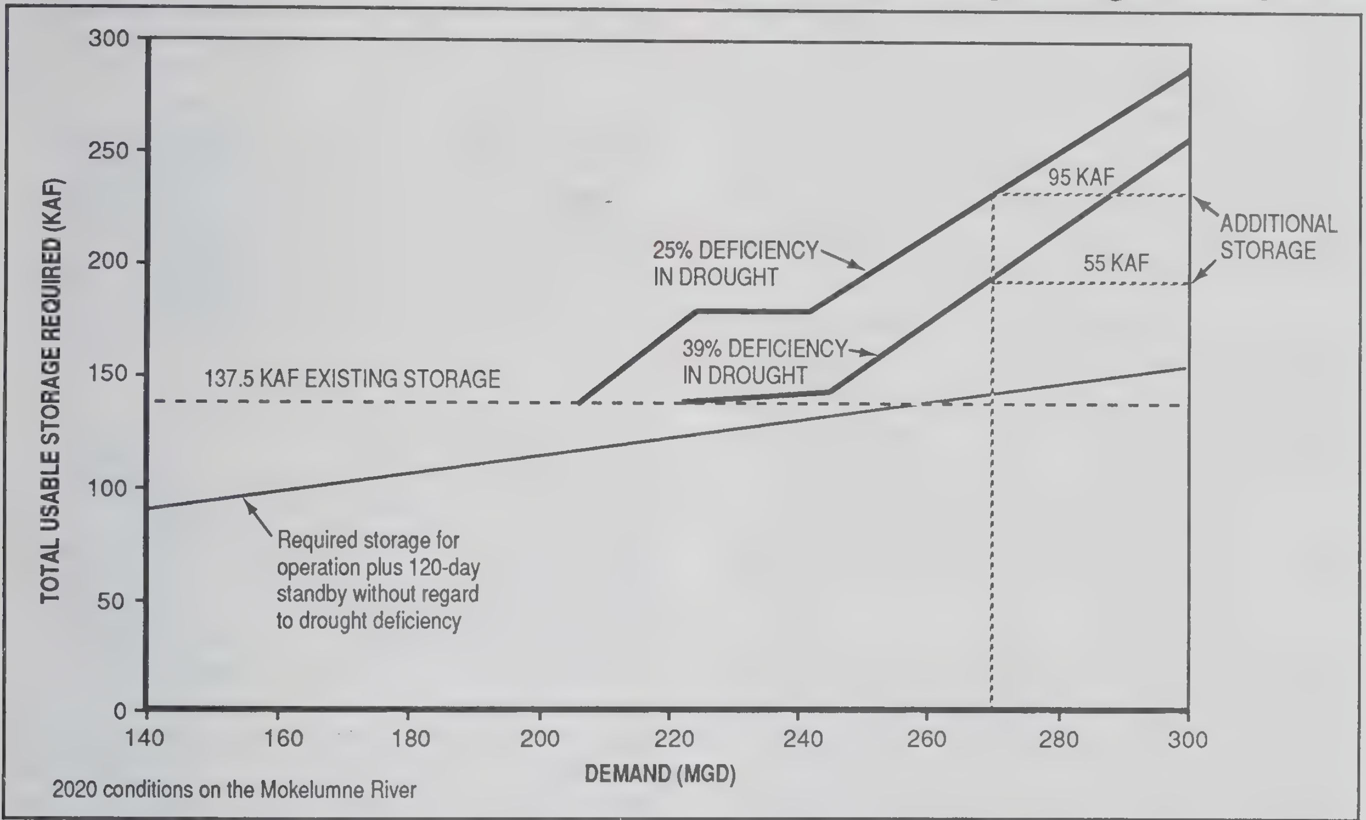
Interties with Other Agencies

The potential for interties with adjacent and nearby water supply systems of other agencies is discussed earlier in this chapter under security alternatives.

An intertie with San Francisco's Hetch Hetchy system would have no benefit in times of shortage during a drought like 1976-77 or the drought currently being faced in 1988 when San Francisco's deficiencies are equal to or greater than EBMUD's.

Terminal Storage Needed to Meet Water Demand During Drought

Figure V-5



The Contra Costa Water District has a sufficient quantity of Delta water available under its USBR contract to provide some water to EBMUD in the event of a dry year shortage, but its quality is inconsistent with the treatment systems at EBMUD's major filter plants and its water quality policy. In the late fall of dry years Delta water quality is at its lowest--the extraordinary high chlorides can be in excess of 250 milligrams per liter and there are very high levels of bromides and organic contaminants from agricultural runoff. If use of Delta water is considered, then EBMUD could pump directly from the Delta. (See discussion of Delta alternative below.)

The State Water Project pumps water from the southern Delta to Bethany Reservoir for the California Aqueduct and for the South Bay Aqueduct extending to southern Alameda County and Santa Clara County. As with the Hetch Hetchy source, a major transmission pipeline would be needed for a connection. It would have to be located between the EBMUD system and either Bethany Reservoir or the South Bay Aqueduct at a cost that may be on the order of $400 million for treatment facilities and a pipeline. As with the CCWD source, the quality of Delta water is inconsistent with the treatment systems at EBMUD's major filter plants and its water quality policy. If use of Delta water is considered, then EBMUD could pump directly from the Delta. (See discussion of Delta alternative below.)

Interties with other agencies are not a viable nor dependable alternative for solving EBMUD's shortage problem. However, they should be considered in water supply management for limited use in emergencies.

Delta Water Use

Water from the Delta is adequate in quantity, but its quality is inconsistent with the treatment systems at EBMUD's major filter plants and its policy on water quality. Delta water is of significantly lower quality than the Mokelumne River, and there is a concern about future public health risks associated with contaminants, particularly organic compounds. The water quality in the Delta is at its worst during dry periods when EBMUD's Mokelumne supply is reduced. EBMUD's water treatment facilities and processes are based on using a high quality source of water and would require extensive capital improvements to treat Delta water. The estimated cost would be on the order of $370 million, for infrequent use of Delta water. Even then, although safe, the treated water would be of lower quality.

During the 1976-77 drought, EBMUD used Delta water mixed with existing supplies. This had potentially adverse effects on the health of its customers. Significant taste and odor problems were experienced. The most serious concern was the increased level of trihalomethanes (THMs), which were caused in large part by elevated levels of bromide from sea water intrusion into the Delta. It took six years for the higher levels of THMs to be flushed out of EBMUD's terminal storage.

Since its inception, EBMUD has maintained a policy of diverting no water from the Delta for delivery to customers (with the 1977 exception). EBMUD's Citizens Advisory Committee in 1985 recommended against such diversions, and state and federal policy urges providing water from the highest quality source. The use of Delta water for delivery to EBMUD customers is not a viable alternative for solving EBMUD's shortage problem.

In response to the 1988 water shortage, EBMUD is exploring the concept of pumping water from the Delta back to Camanche Reservoir on the Mokelumne River, using one of the Mokelumne Aqueduct pipelines in a reverse direction. This could provide some of the water for EBMUD's obligatory releases into the lower Mokelumne River and allow an equivalent amount of higher quality water to be diverted at Pardee Reservoir for additional delivery to the East Bay area. If it turns out to be feasible and effective, it would offset some of the rationing that is required and for the future would be included in EBMUD's water supply management.

Exchange with Woodbridge Districts

Agreements between EBMUD and the Woodbridge Irrigation District and Woodbridge Water Users Conservation District provide that EBMUD will release enough water from Camanche Reservoir each year so that a Permanent Regulated Base Supply of 39,000 to 60,000 acre-feet, depending on inflow to EBMUD's reservoirs, is available for use by the Woodbridge districts; with sufficient additional releases through 1992 so that an Interim Supply of 26,855 to 56,700 acre-feet, depending on inflow and EBMUD's diversions, is also available to those districts. These agreements recognize the relative rights to Mokelumne River water held by each district.

In the Woodbridge exchange concept, EBMUD would provide a water supply to the Woodbridge districts from some other source in exchange for a commitment by those districts to reduce their Mokelumne River diversions. The other source could be from the Eastern Delta (about $25 million for new facilities). A small amount of water could be available from possible groundwater sources in the Woodbridge area.

The Woodbridge exchange would have a limited benefit to EBMUD because the quantity of water would not solve EBMUD's problem of shortage in drought periods. Furthermore, the resulting decrease in river flows below Camanche Reservoir would be a significant concern to the fish and wildlife agencies and would have an adverse impact on the groundwater basin, which could reduce the already limited quantity available.

Conclusions Regarding Shortage Alternatives

From the above analysis of shortage alternatives, the most feasible and cost-effective approach to solving the problem of water shortage during a drought is water banking with the construction of additional terminal storage. Also, it offers the possibility of a multi-purpose solution in conjunction with the problem of security. Capacity should be based on surviving a repeat of a drought like 1976-77 and a projected demand of 270 MGD in 2020, which is the mid-range growth rate and assumes full implementation of current water conservation and reclamation programs. A 25 percent demand reduction during the second year of the shortage should be part of the planning to reduce the severity of rationing and accommodate increased efficiency of water use. The amount of the additional storage would be 95,000 acre-feet at an estimated cost of $115 to $146 million. The integration of this capacity with the storage required for security is discussed later in this chapter.

Water conservation cannot solve the shortage problem unless normal year demand is significantly reduced by unusual mandatory measures, with major investment by customers in water saving equipment and impacts on the economy and lifestyle of the East Bay area.

Any consideration of implementing the American River supply under the USBR contract is delayed by the ongoing litigation, and therefore it is not considered an alternative at this time. This does not affect the selection of water banking as the most-feasible alternative, as discussed later in this chapter.

The Delta could provide an adequate quantity of water, but the quality under normal conditions is inconsistent with EBMUD treatment systems and its policy on water quality. During drought the flows into the Delta are lower, further lowering the quality particularly in the fall. The concept of pumping water from the Delta back to Camanche Reservoir is being explored in response to the 1988 water shortage. This

could provide some of the water needed for EBMUD's obligatory releases into the lower Mokelumne River and would offset some of the rationing required.

Other options would not be solutions to the shortage problem, but would provide benefits and should be pursued as part of a balanced water supply management program: Additional water conservation measures and wastewater reclamation projects to increase the efficiency of water use; exchange of water with the Woodbridge districts; and conduct studies of intertie improvements with other agencies.

ANALYSIS OF SAFETY AND HEALTH ALTERNATIVES

Need for Improvements

Although EBMUD treated water is superior to state and federal standards, EBMUD continues to modernize its treatment plants, improve its taste and odor control capabilities, pursue advance treatment technologies in anticipation of future drinking water regulations, and evaluate future alternative treatment technologies. EBMUD is currently undertaking approximately $35 million in improvements as part of its ongoing treatment improvement program.

EBMUD owns approximately 26,000 acres of watershed land in the East Bay area. The East Bay Regional Park District and other public agencies own about 20,000 acres of open space contiguous with EBMUD's watershed lands. Watershed management is essential to providing high quality water to prevent sewage and other pollutants from entering the terminal reservoirs. Ongoing watershed reconnaissance, water quality monitoring, and land management activities will continue.

Watershed Enhancement

Watershed management would be improved by EBMUD's purchase of watershed lands currently in other ownership and which may have a potential for development. Acquisition of the land to the ridgelines around the terminal reservoirs to the extent possible would help assure that the high quality of stored water can be maintained in the future. Acquisitions could also minimize ridgeline development in the Moraga/Orinda area (San Pablo and Upper San Leandro watersheds) and provide opportunities for significant trail enhancement. A program for acquiring about 3,500 acres of watershed has an estimated cost of $20 million.

CONCLUSIONS ON THE MOST-FEASIBLE PROGRAM ALTERNATIVES

Water Banking--Additional Terminal Storage

From the conclusions related to both security and shortage needs, water banking appears as the most-feasible and cost-effective solution. Thus, it would be a multi-purpose solution to EBMUD's water supply needs. It would also meet the water quality objective related to safety and health because the stored water would be from the Mokelumne River.

The storage required at a future demand of 270 MGD in 2020 is shown in Figure V-6. The capacity required for surviving a drought like 1976-77 and surviving a 13-month outage of the Mokelumne supply are shown as separate considerations. Also shown is the capacity needed for a condition where a major earthquake affecting the Delta and a worst-case drought occur in immediate sequence. However, the risk of sequential events is very small and the proposed storage would therefore be based on security, which has the greater requirement. If the planned demand reduction (rationing) during an outage is kept at the current policy level of 39 percent, the additional terminal storage would be 100,000 acre-feet. But the planned demand reduction should be reduced to 25 percent to reduce the severity and to accommodate increased water use efficiency. In that case the proposed storage is 145,000 acre-feet.

Additional Storage Required — Figure V-6

RATIONING: Demand Reduction	SECURITY: 13-month Supply Outage	SHORTAGE: Repeat of 1976-77 Drought	Sequential Events
39%	100,000 AF	55,000 AF	150,000 AF
25%	145,000 AF	95,000 AF	235,000 AF

AF= acre-feet

Watershed Enhancement

To meet the safety and health objective of maintaining high quality water, acquire additional watershed land to the ridgelines around the terminal reservoirs to the extent possible, at an estimated cost of $20 million.

Other Considerations

From the discussions of alternatives for security, shortage, and safety and health, several other options emerge which do not solve the water supply problems, but provide benefits and are important to a

complete and balanced water supply management program:

- Water conservation---continue implementation of the current program and adopt additional measures, which would save 7 MGD by 2020; continue analyses and studies for future expansion of the program.

- Water reclamation---continue to develop reclamation projects, which would save about 5 MGD by 2020; seek additional opportunities for feasible projects.

- Levee and foundation improvements in the Delta:

  - Continue levee maintenance, repair, and upgrading to offset the deteriorating conditions in the Delta.

  - Investigation and feasibility studies of levee reinforcement and of modification of supports under the existing aqueduct pipelines to reduce the risks of aqueduct damage due to flooding and lower levels of ground shaking caused by earthquakes.

  - Field testing and preliminary design of possible pile support systems and a future aqueduct pipeline across the Delta to shorten the response time in the event of a disaster.

- Intertie improvements with other agencies---undertake studies to increase the capacity of the existing connections with the Hetch Hetchy system through the City of Hayward and to further explore the feasibility of a direct intertie with the Hetch Hetchy system.

- Woodbridge exchange---continue to explore the possibility of exchanging water with the Woodbridge districts to increase the water available from the Mokelumne River during shortages.

- Treatment improvement program---continue the treatment plant improvements at a cost of $35 million. At the same time continue to pursue advance treatment technologies.

Compatibility with Future Decisions and Needs

A decision to construct additional terminal storage for solving the problems of security and shortage and other elements of water supply management should be compatible with any future decisions regarding EBMUD's water supply needs. Selection of a proposed program today will be based on a reasonable assessment of conditions in the next decade and extending out more than 30 years to 2020. Conditions can be expected to change within that period, and EBMUD's water supply needs will extend on into the future beyond 2020.

If demand continues to increase beyond the year 2020 to levels higher than 270 MGD, terminal storage will again become insufficient to provide security against an extended outage of water supply delivery system and additional facilities would have to be constructed. The construction of additional terminal storage now and levee and foundation improvements in the Delta would be consistent with the long-term security needs.

Implementation of EBMUD's contract with the USBR for a supplemental supply from the American River may be decided in the next few years, after the current litigation is resolved. The construction of additional terminal storage now would have no effect on such a decision because the terminal storage is needed with or without the supplemental supply. Security against an extended outage of EBMUD's delivery system due to a disaster in the Delta is needed regardless of the source of water---Mokelumne or American River---and regardless of the increased supply that would become available. While use of supplemental water would help reduce the severity of rationing during a drought shortage, in the current litigation EBMUD has proposed to avoid taking delivery of water when minimum flow standards are not met in dry years in the lower American River.

This would result in EBMUD not taking delivery of water in a drought year like 1977, and therefore storage would be needed to carry over that supply to years when it is needed. Another consideration is the terminal storage needed for operational and minimum standby needs, even during a shortage. Current terminal storage is adequate only up to a normal demand of 252 MGD, so the additional storage is required for those functions, regardless of the source of water.

Watershed enhancement to protect the quality of EBMUD's water supply is equally important with or without the supplemental supply from the American River.

TERMINAL RESERVOIR SITE

Initial Investigation

Consideration was given to 26 potential reservoir sites throughout the service area, as well as to raising EBMUD's existing dams, and removing silt from existing reservoirs.

None of EBMUD's existing dams was designed with provisions to increase the capacity of the reservoirs in

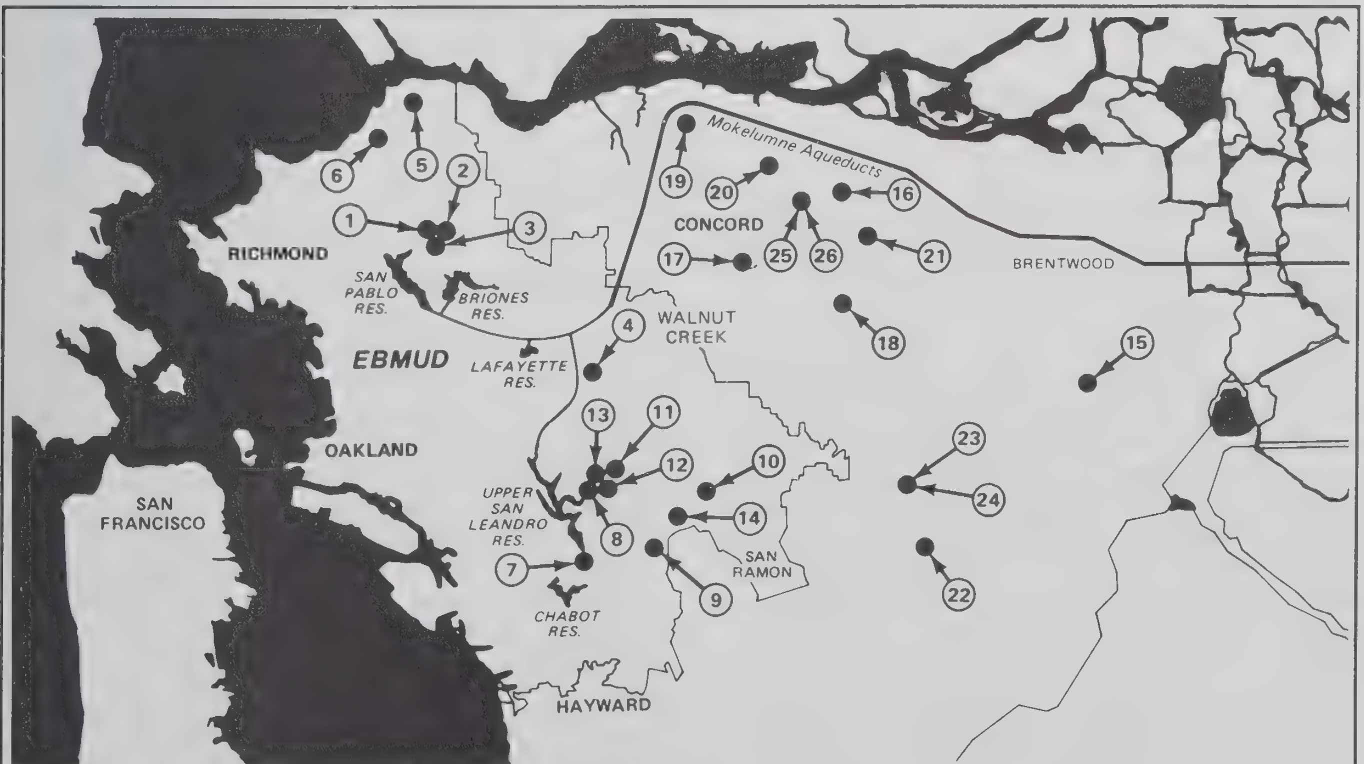
the future. To increase the volume of EBMUD's existing reservoirs, by 100,000 to 145,000 acre-feet, the reservoirs would require draining before the construction work could be performed. Raising Upper San Leandro Dam would cause flooding of the City of Moraga unless a second dam were built. Raising San Pablo Dam would cause flooding of Orinda Filter Plant, JFK University, San Pablo Dam Road, and the City of Orinda. It would also cause inundation of the downstream face of Briones Dam. Raising Briones Dam would require reconstruction of the existing dam because of its non-symmetrical distribution of core material. Chabot and Lafayette Reservoirs which have existing capacities of 10,300 and 4,200 acre-feet have very small watersheds. To increase their capacities by 100,000 to 145,000 acre-feet would not be feasible. The cost and the temporary loss of supply during construction would not warrant further consideration of raising any of the existing dams.

Figure V-7 identifies the locations of the 26 dam sites that were identified and evaluated. The sites can be grouped into three general areas: West Contra Costa County, South Alameda County, and East Contra Costa County. To reduce the number of alternatives to be retained for final evaluation, the alternatives were screened based on reservoir size, capital cost, land use, and operational considerations.

Early in the planning process the minimum size of reservoir was determined to be approximately 30,000 acre-feet. Capital costs included the cost of the dam, appurtenances, and conveyance facilities. Land use considerations included the potential impact on housing, transport, and public use facilities. Operational considerations included the reservoir location relative to the District's water supply and distribution system.

Potential Reservoir Sites

Figure V-7



1	Pinole	10	Bollinger Canyon	19	Nichols
2	Upper Pinole A	11	Upper Kaiser	20	Bailey Road
3	Upper Pinole B	12	Kaiser	21	Morning Side
4	Tice Valley	13	Upper Buckhorn	22	Alamo Creek
5	Canada del Cierbo	14	Bolinas	23	High Tassajara
6	Rodeo Canyon	15	Los Vaqueros	24	Low Tassajara
7	San Leandro	16	Sidney Flat	25	High Kirker
8	Buckhorn	17	Curry Canyon	26	Low Kirker
9	Cull Canyon	18	Mitchell Canyon		

Figure V-8 summarizes the sizes and capital costs of the reservoir alternatives and the reasons for their rejection or retention for final evaluation. The Pinole site is clearly the most cost effective of the sites in West Contra Costa County. Many sites in East Contra Costa County had also been studied by the Contra Costa Water District, and the Los Vaqueros site is clearly the most cost effective of the sites in this region. In South Alameda County, the San Leandro and Buckhorn sites appear to be the most cost effective. However, the San Leandro site has a major operational drawback. San Leandro Reservoir would operate in conjunction with Upper San Leandro (USL) Reservoir and would be capable of serving only USL filter plant. In addition, San Leandro Reservoir would contain a large amount of unusable storage (40 percent of the total volume) below the minimum water surface elevation needed to operate USL Filter Plant.

Based on the criteria above, the alternatives selected for final evaluation were:

- Pinole
- Buckhorn
- Los Vaqueros

The site locations are shown in Figure V-9.

Final Site Evaluation

Figure V-10 summarizes the final evaluation of Pinole, Buckhorn, and Los Vaqueros Reservoirs. Details of the costs may be found in Appendix B.

PINOLE RESERVOIR

Pinole Reservoir, shown in Figure V-11, is located on Pinole Creek between Pinole and Sobrante Ridges just northeast of San Pablo Reservoir and southeast of the City of Pinole. Reservoir sizes under consideration range from 29,000 acre-feet to 50,000 acre-feet, most of which would be usable storage. Spillway crest elevations range from 313 feet to 340 feet, and dam heights range from 150 feet to 180 feet. A preliminary study for the smaller dam was completed in 1958.

Spillway Crest Elevation (Feet)	Dam Height (Feet)	Reservoir Capacity (KAF)	Usable Volume (KAF)
313	327	29,000	25,000
340	355	50,000	44,000

A chute spillway, located on the right abutment, would discharge into Pinole Creek downstream from the dam. An inlet-outlet tower would be located near the left abutment of the dam and would serve three functions: (1) flow into Pinole Reservoir; (2) releases to San Pablo Reservoir or Sobrante Filter Plant; and (3) reservoir blowoff to Pinole Creek. A pumping plant would not be required for the smaller reservoir because it would operate in conjunction with San Pablo Reservoir, which has the same spillway crest elevation.

For the larger reservoir, the pumping plant would be located just below San Pablo Dam, southwest of San Pablo Creek and the Sobrante Raw Water Aqueduct. Water would be pumped from the existing San Pablo Reservoir through the Sobrante Aqueduct, through 4,000 feet of new 72-inch pipe, and then 5,000 feet of tunnel to Pinole Reservoir. The Pinole Pumping Plant is located on District property at an elevation low enough for successful operation. This site has better access than alternative locations and thereby a lower construction cost. Figure V-12 shows the hydraulic operation for Pinole Reservoir.

The water quality in Pinole Reservoir is difficult to assess prior to construction. The water quality will depend on several factors, such as source of water, soil characteristics of the watershed, depth of reservoir, and residence time. Pinole Reservoir would be filled from San Pablo Reservoir and would therefore require full treatment similar to that provided for water from San Pablo Reservoir. Pinole Reservoir, with a maximum depth of about 180 feet, is a relatively shallow reservoir and would therefore be more susceptible to taste and odor problems than a deeper reservoir would be.

BUCKHORN RESERVOIR

Buckhorn Reservoir is located about 1-½ miles north of USL Dam in a narrow arm of USL Reservoir. Five alternative dam axis locations were evaluated, and the location shown in Figure V-13 was selected because (1) it has the smallest dam section, (2) it retains the largest reservoir capacity, and (3) it is founded entirely on Pinoche formation, which is competent bedrock material requiring minimal foundation treatment. Reservoir sizes under consideration range from 80,000 acre-feet to 145,000 acre-feet with dam heights ranging from 305 feet to 370 feet. Geographically, Buckhorn Reservoir has the advantage of being able to serve any of the District's filter plants by gravity. The dam would be an earthfill embankment with a spillway approximately 30 feet wide on the left abutment.

Spillway Crest Elevation (Feet)	Dam Height (Feet)	Reservoir Capacity (KAF)	Usable Volume (KAF)
680	305	80	78
735	360	134	132
745	370	145	143

Preliminary Reservoir Site Evaluation

Figure V-8

RESERVOIR SITE	TOTAL STORAGE KAF	TOTAL COST* $ Millions	UNIT COST $ Millions/KAF	REASON(S) FOR REJECTION
WEST CONTRA COSTA COUNTY				
Pinole	50.0	65	1.3	Retained for final evaluation
Upper Pinole A	37.0	70	1.9	a
Upper Pinole B	46.0	90	2.0	a
Tice Valley	60.0	120	2.0	a,c
Canada del Cierbo	14.2	180	12.7	a,b,c
Rodeo Canyon	15.0	N/A	N/A	b,c
NORTH ALAMEDA COUNTY - SOUTH CONTRA COSTA COUNTY				
San Leandro	68.0	80	1.2	e
Buckhorn	145.0	165	1.1	Retained for final evaluation
Cull Canyon	50.0	110	2.2	a,c
Bollinger Canyon	50.0	165	3.3	a,c
Upper Kaiser	36.0	170	4.7	a
Kaiser	11.0	65	5.9	a,b
Upper Buckhorn	14.0	60	4.3	a,b
Bolinas	56.0	200	3.6	a
EAST CONTRA COSTA COUNTY				
Los Vaqueros(1)	77.0	130	1.7	Retained for final evaluation
Sidney Flat	62.0	N/A	N/A	c,d
Curry Canyon	50.0	115	2.3	a
Mitchell Canyon	50.0	200	4.0	a
Nichols	9.0	N/A	N/A	b,d
Bailey Road	3.0	N/A	N/A	b,d
Morning Side	15.0	N/A	N/A	b,d
Alamo Creek	32.0	190	5.9	a
High Tassajara	38.0	220	5.8	a
Low Tassajara	28.0	180	6.4	a
High Kirker	50.0	185	3.7	a,d
Low Kirker	26.0	80	3.1	a,d

NOTES:

(1)One joint project with Contra Costa Water District

a Unit cost greater than that of comparable site(s)

b Reservoir capacity does not meet minimum requirement of 30,000 acre-feet (approximately).

c Reservoir would displace major housing, transport or public use facilities.

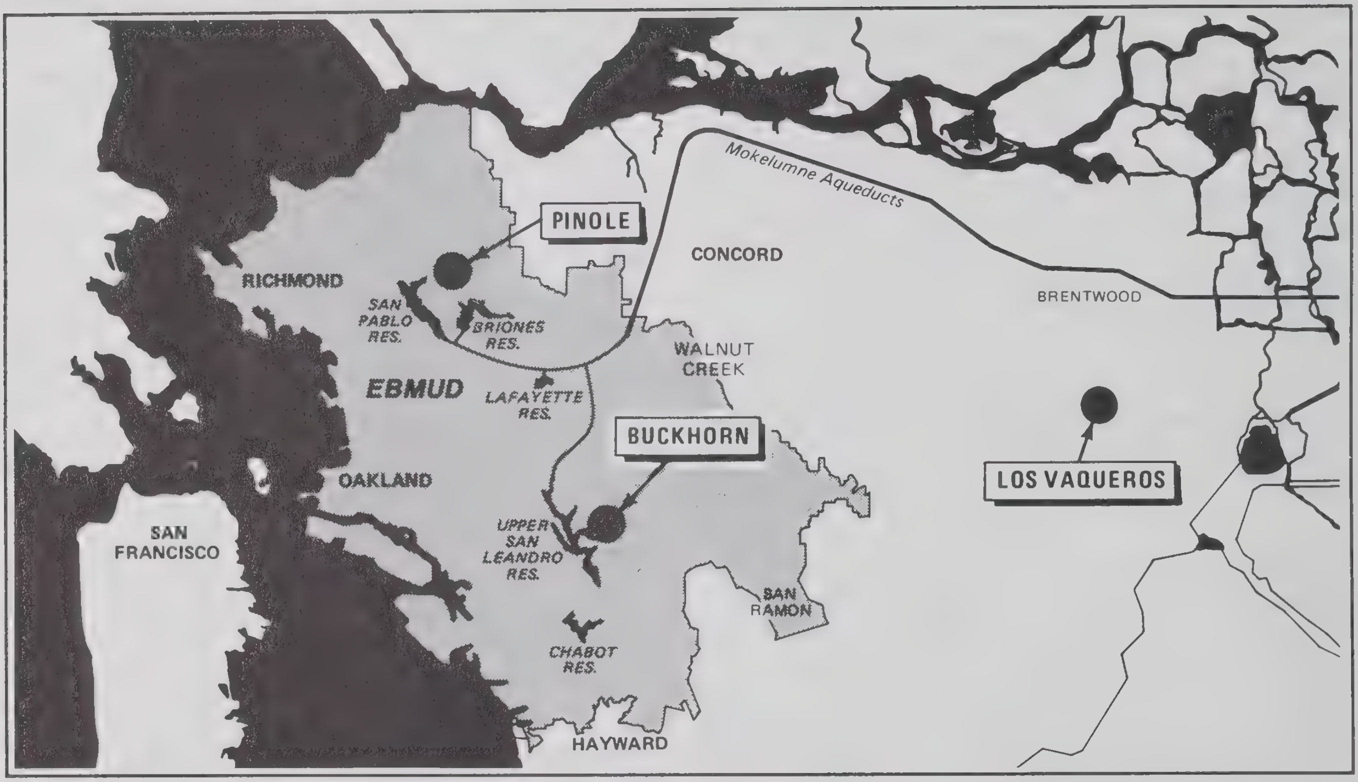
d Studied and rejected by Contra Costa Water District and addressed in Los Vaqueros EIR.

e Reservoir location not compatible with distribution system.

*Total cost in 1987 dollars.

Alternative Reservoir Sites

Figure V-9



A Buckhorn dam with spillway crest elevation above 680 feet would require, in addition to the main dam, two small dikes on the ridge south of the proposed reservoir. At spillway crests below 735 feet, the dikes may be composed of earthfill material. At spillway crests above 735 feet, the dikes would be constructed of rockfill or rolled compacted concrete.

The reservoir would be filled via the existing Moraga Aqueduct and a new pumping plant would be built near St. Mary's College in Moraga. The plant would take suction from the Moraga Aqueduct and discharge through 23,000 feet of new 84-inch pipe, then through 6,000 feet of 90-inch tunnel leading to the reservoir. Figure V-14 shows the hydraulic operations for Buckhorn Reservoir.

Five tunnel alignments were evaluated in the Geologic Reconnaissance Study (June 1987). The preferred location passes through only one geologic formation, the Claremont formation. The other alignments cross up to four geologic units and a fault zone and traverse beneath thin ground cover. The portals of these alternative alignments also lie in the base of a landslide area. Two alternative alignments to reduce the cost of shortening the length of tunnel were also considered. The first alignment evaluated a 72-inch pipeline route from St. Mary's College (570') to the reservoir with no tunnel. A pumping plant would be necessary to pump water over a hill at elevation 1100'. Another pumping plant would be required at Buckhorn Reservoir to pump water back over the hill and into the Lafayette Aqueducts. Because of the additional pumping requirements associated with a pipeline alignment, this alternative proved to be more expensive and was eliminated from further consideration. The second alignment, extending along USL Reservoir, was eliminated from further consideration because it did not shorten the tunnel enough to reduce cost significantly. In addition, the portal of this alignment would not provide adequate space for a tunnel staging area.

When necessary, water from Buckhorn Reservoir would be delivered by gravity back through the tunnel, the new pipeline, and the Moraga Aqueduct to the District's filter plants. The Buckhorn Pumping Plant is located at the high point of the Moraga Aqueduct and results in lower energy costs to fill the reservoir. Three alternative locations for the pumping plant were considered. The selected location eliminates the need to create a closed piping system that would require a surge stack and dissipater at St. Mary's College.

The water quality in Buckhorn Reservoir is difficult to assess prior to construction. However, there are two factors which indicate that favorable water quality conditions will occur in the reservoir. First, the reservoir would be filled with high quality Sierra water directly off the Mokelumne Aqueducts. Second,

Comparison of Terminal Reservoir Alternatives

Figure V-10

ALTERNATIVE	CAPITAL COSTS[1]		STORAGE VOLUME		INCREASE IN AVAILABLE SUPPLY[2] (MGD)	DROUGHT RECOVERY TIME[3] (Months)	DEFICIENCY[4] During 13 Mo. Outage (%)	WATER QUALITY	ENVIRONMENTAL IMPACTS[5]
	Total Cost ($ Mil)	Unit Costs ($ Mil)	Total Volume (KAF)	Usable Volume (KAF)					
PINOLE								Would be filled with San Pablo Reservoir water and will require full treatment similar to San Pablo Reservoir water.	Impacts on riparian habitat. Possible disturbance to rare and endangered species of Aleutian Canada Goose. Temporarily increased truck traffic on local roads, particularly on Castro Ranch Road and Pinole Valley Road.
313'	$ 55	$2.20	29	25	15	10	62		
340'	$ 65	$1.48	50	44	23	12	56		
LOS VAQUEROS[6]								A viable alternative for EBMUD only if Mokelumne River water or equally high quality water is used to fill it.	Impacts on riparian habitat. Temporary increase in truck traffic on local roads, particularly on Vasco Road and Walnut Boulevard.
560'	$200	$1.38	155	144	66	48	25		
BUCKHORN								Protected watershed. Would be filled with Mokelumne River water. Direct filtration only unless fed into Upper San Leandro or San Pablo Reservoirs.	Impacts on riparian habitat. Temporary increase in truck traffic on local roads, particularly on Redwood Road and Miller Road.
680'	$115	$1.47	80	78	32	23	45		
745'	$170	$1.18	145	143	66	48	25		

NOTES:

(1) Costs shown are in 1988 dollars.

(2) Numbers are based on the maintenance of 120-day Standby Supply for outages during all hydrologic conditions including very dry years. Assumes 25% reduction in demand in dry years.

(3) Indicates time needed for terminal reservoirs to recover from a repeat of the 1976/77 drought if operated to achieve increase in reasonable yield.

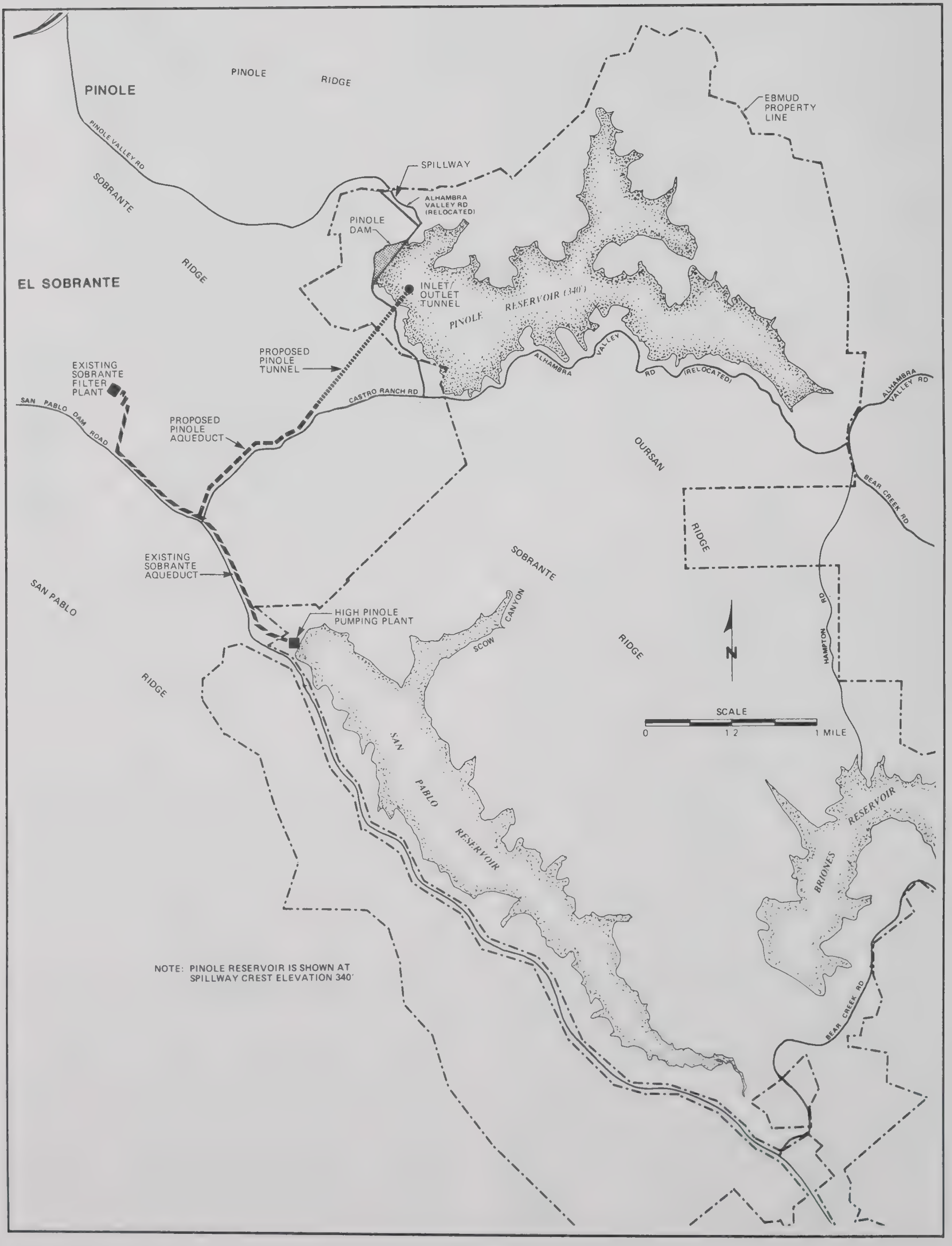
(4) Deficiencies are based on year 2020 projected demands.

(5) Detailed assessment of environmental impacts of Buckhorn (745'), Los Vaqueros (560') and Pinole (340') are made in the Draft EIR.

(6) Costs would vary; costs shown are based on one possible joint project with Contra Costa Water District.

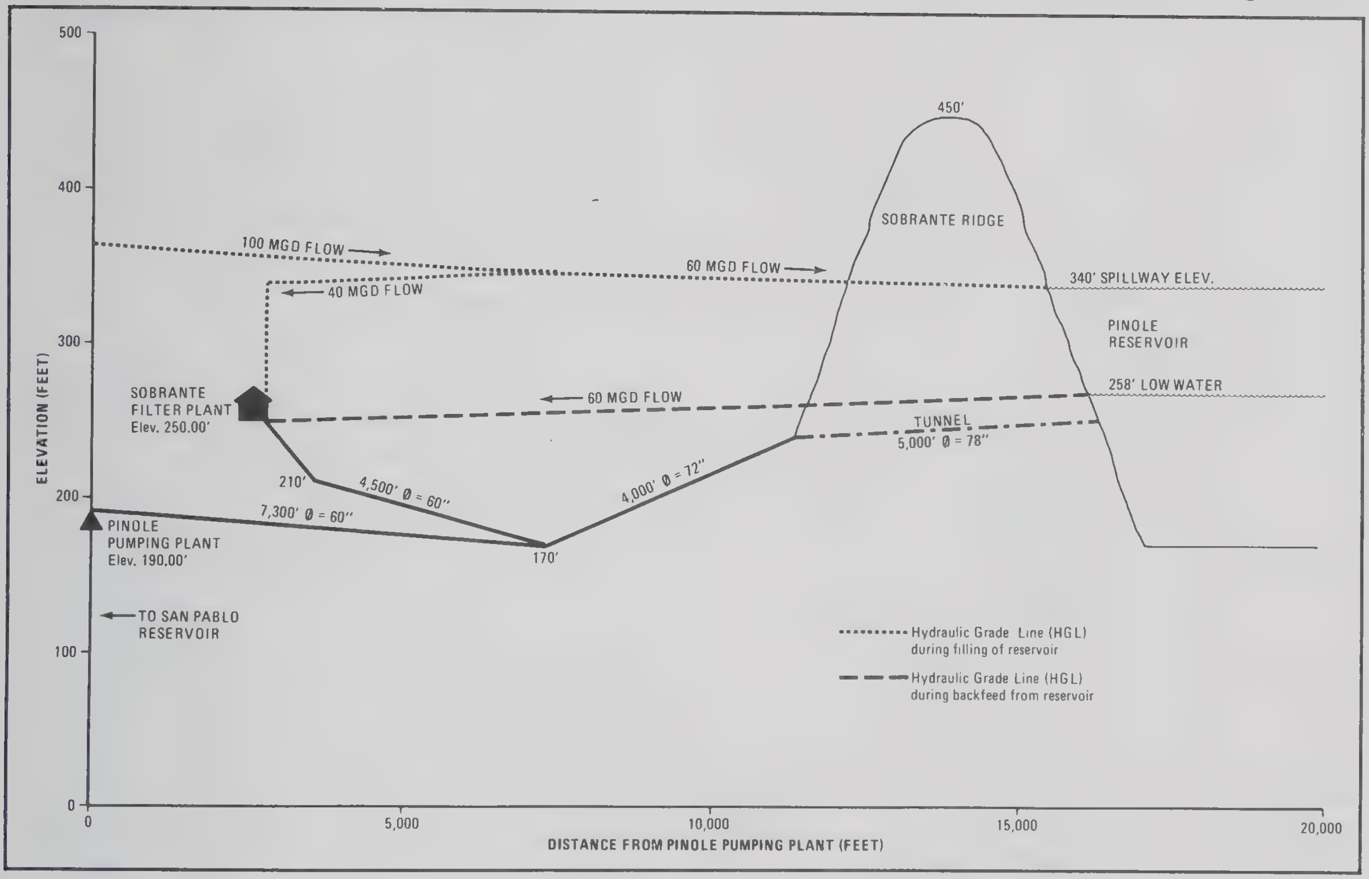
Pinole Reservoir (340')

Figure V-11



Operation of Pinole Reservoir

Figure V-12



with a maximum depth of 370 feet, Buckhorn Reservoir is relatively deep and would therefore be less susceptible to taste and odor problems.

LOS VAQUEROS RESERVOIR

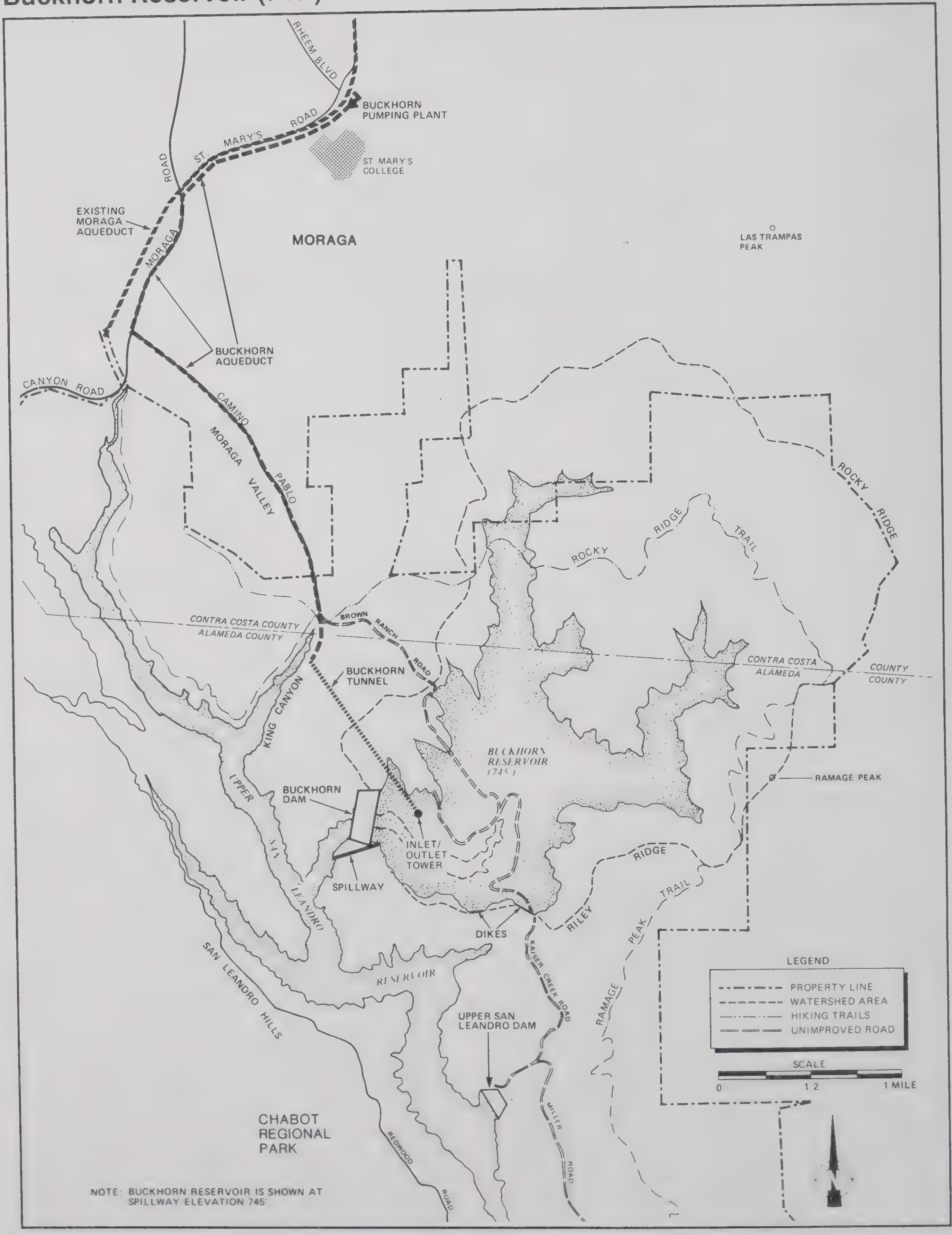
The Los Vaqueros site, shown in Figure V-15, is located on the western side of the Delta, approximately nine miles south of the City of Brentwood. The reservoir would store water from the Mokelumne Aqueducts via a connection near Brentwood. This site has been evaluated by the State of California for the State Water Project and by the Federal government for the Central Valley Project, as well as Contra Costa Water District (CCWD). CCWD is in the process of acquiring the property and developing a specific reservoir project for use in its system and is interested in a joint project with EBMUD and other agencies. The draft EIR on Stage 1, which covers land acquisition for the Los Vaqueros/Kellogg Project was completed in May 1986. The size of Los Vaqueros Reservoir could range from 50,000 to 1,000,000 acre-feet. The draft EIR for Stage 2 which covers the environmental impacts of constructing Los Vaqueros is anticipated after November 1988.

To be consistent with EBMUD's objective to serve high quality water and compatible with EBMUD's existing treatment facilities, a joint project with CCWD would require storage of Sierra water in Los Vaqueros. Currently, CCWD takes its water supply from the Delta at Rock Slough. Delta water quality, especially temperature, turbidity, and algal activity, is subject to significant fluctuations. During periods of low runoff, Delta water quality can fluctuate depending upon Delta inflows, Delta exports, and Delta outflow to San Francisco Bay. CCWD has experienced degradation in the quality of its Delta water supply in the form of high chloride levels due to low runoff of fresh water into the Delta. CCWD is presently preparing an EIR to purchase EBMUD's surplus Mokelumne water on an interruptible basis in an effort to improve their water quality at these times.

One possible joint project with CCWD would be a reservoir that provided a minimum of 144,000 acre-feet of usable storage for EBMUD. As shown in the following table, the total reservoir size would have to be approximately 265,000 acre-feet to meet both

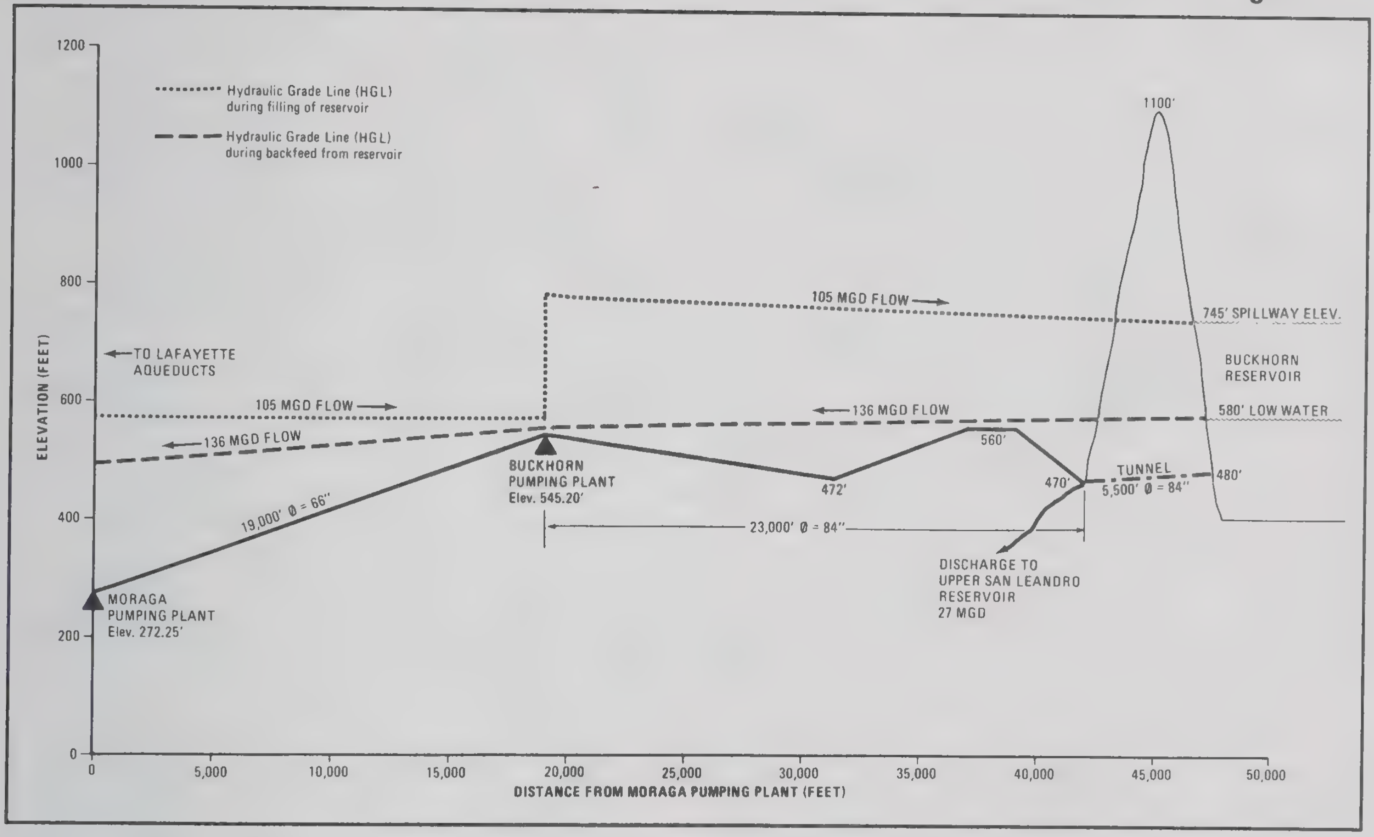
Buckhorn Reservoir (745')

Figure V-13



Operation of Buckhorn Reservoir

Figure V-14



CCWD's and EBMUD's needs. It is estimated that approximately 13,000 acre-feet would be unusable storage.

Storage Purpose	CCWD	EBMUD	Total
Usable Storage	100 KAF	144 KAF	244 KAF
Flood Control	4 KAF	4 KAF	8 KAF
Unusable Storage	6 KAF	7 KAF	13 KAF
TOTAL	110 KAF	155 KAF	265 KAF

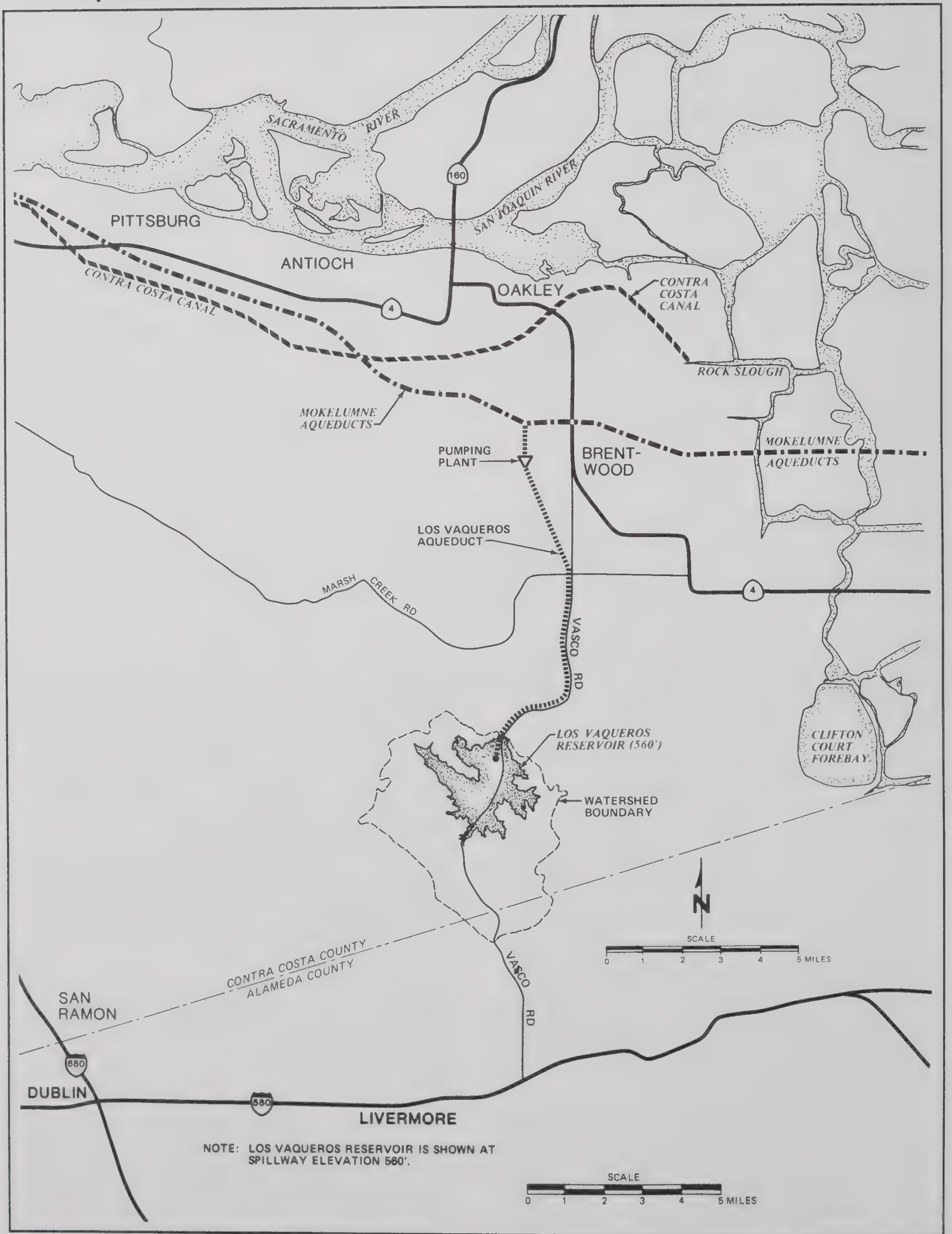
A reservoir with 265,000 acre-feet of storage would have an approximate spillway crest elevation of 560 feet. At this elevation, only one main embankment, about 270 feet high, would be necessary for the creation of the reservoir. When the storage of the reservoir exceeds approximately 400,000 acre-feet, saddle dams would be required.

As a joint EBMUD-CCWD project, Los Vaqueros would be filled with surplus Mokelumne water from the Sierra Nevada. If EBMUD has separate facilities, a 66-inch diameter pipeline would be needed to transport water into EBMUD's service area during an emergency outage. The pumping plant could be located at a number of sites, but should be located in an area below 100 feet in elevation to provide adequate suction for the pumps. One option for the pumping plant is Fairview Avenue near Dainty Road. The reservoir would be filled from the Mokelumne Aqueducts at a point near Oakley through approximately 50,700 feet of 66-inch diameter pipeline to a 72-inch diameter tunnel into the reservoir. The pipeline could also connect with the CCWD's Contra Costa Canal, which is approximately 2.5 miles north of the Mokelumne Aqueducts. The tie-in point on the Contra Costa Canal would be just upstream of CCWD's Pumping Plant No. 4.

EBMUD would operate its portion of Los Vaqueros Reservoir similar to Buckhorn Reservoir. When excess supply from the Mokelumne Aqueduct is available, water would be pumped from the aqueduct to the reservoir. When water is needed from the reservoir, water would flow by gravity or be pumped through the pipeline into the Mokelumne Aqueducts. Figure V-16 shows the hydraulic operations for Los Vaqueros Reservoir. CCWD would operate its portion of the reservoir differently, purchasing its supply of water from EBMUD or obtaining another source of water of equivalent quality.

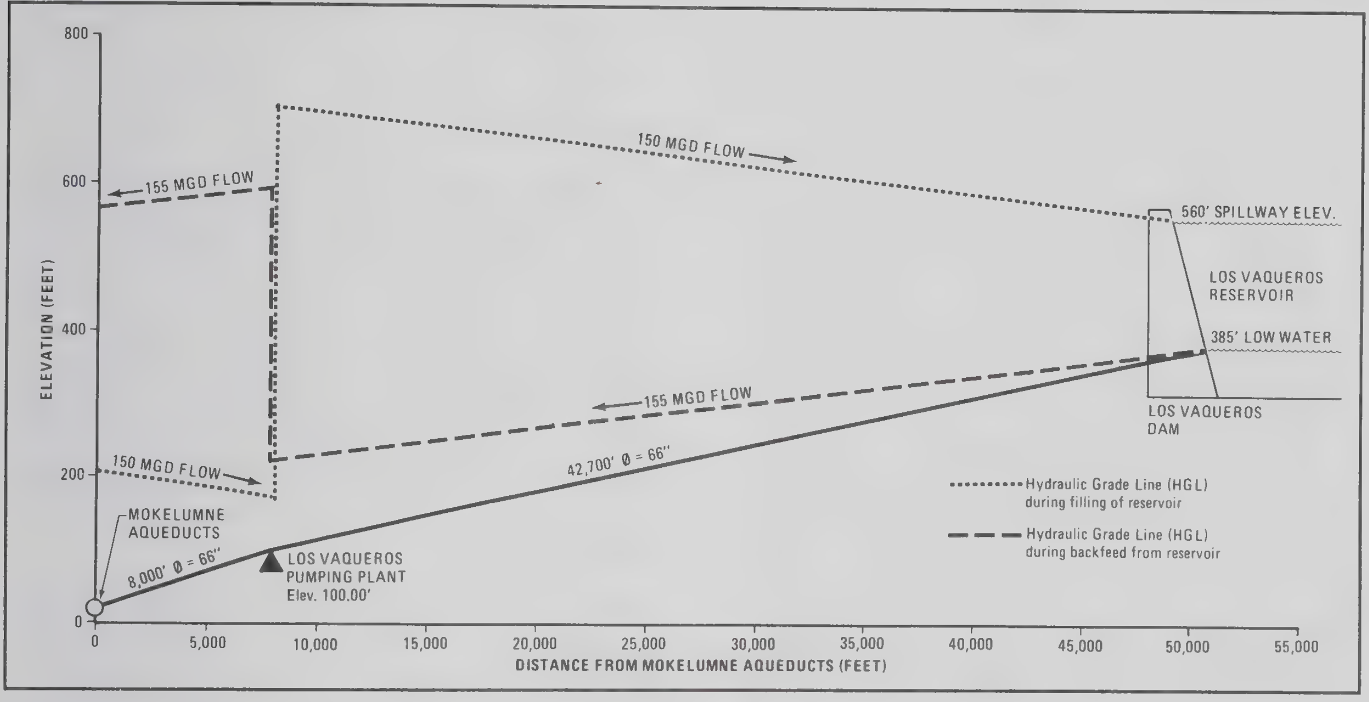
Los Vaqueros Reservoir (560')

Figure V-15



Operation of Los Vaqueros Reservoir

Figure V-16



Considerable geotechnical work has been done to evaluate potential dam sites for Los Vaqueros Reservoir. These include studies by the DWR, the USBR, and private consultants for CCWD. The most recent study, by Woodward-Clyde Consultants, was performed in 1987 and utilized the previous studies along with further field investigations. This study identified four potential dam sites along Kellogg Creek and concluded that the location proposed (See Figure V-15) would be the most feasible. The proposed location of the dam would minimize the construction cost because it would minimize the volume of the dam embankment.

While Los Vaqueros Reservoir would meet all three EBMUD objectives, it is not located within the District's service area. This could present a problem because, if an aqueduct outage occurred between the reservoir and the service area, water from the reservoir could not be used. Because Los Vaqueros would be filled with Mokelumne water which is surplus to EBMUD's needs, the quantity of water EBMUD could provide to CCWD may be less than they desire.

Site Selection

The storage needed for both security and shortage is 145,000 acre-feet.

Of the three best alternatives, Pinole, Buckhorn, and Los Vaqueros, only two provide adequate storage to meet the security and supply objectives. They are Buckhorn and Los Vaqueros.

Site Options	Usable Storage	Capital Costs*
Buckhorn (745')	143,000 acre-feet	$152M
Los Vaqueros (560')	144,000 acre-feet (EBMUD only)	$185M

*Costs in 1988 dollars & do not include initial filling of reservoir

Los Vaqueros would in all likelihood be a joint project with CCWD and other agencies. EBMUD would participate in such a joint project only if the reservoir would be filled with Sierra water. Because of the urgency to address EBMUD's near-term water supply issues and the complexities associated with a joint Los Vaqueros Project with CCWD, Buckhorn Reservoir should be given further consideration.

Buckhorn Reservoir would be located within the District's service area. It would be a deep reservoir in a remote area with a protected watershed. This would make it easier to control activities on the watershed and taste and odor problems in the reservoir.

Buckhorn Reservoir with a total storage capacity of 145,000 acre-feet is the recommended site if additional terminal storage is constructed.

WATER QUALITY ANALYSIS OF TERMINAL RESERVOIR SITES

Chapter IV concluded that terminal reservoirs should be filled with only high quality Sierra sources to avoid water quality problems such as those experienced by EBMUD with the use of Delta water during the 1976-77 drought. These water quality concerns include excessive salinity, high THM formation potential, taste and odors, and incompatibility with the District's water treatment system.

Terminal reservoir watersheds should also be protected from urban development to prevent pollution caused by urban runoff which leads to toxic and carcinogenic chemical contamination, sewage contamination, taste and odors, siltation, and increased treatment costs. A fully protected watershed would allow less costly direct filtration treatment to be applied to the water.

Terminal reservoirs should also be as deep as possible to allow the selection of water at depths below taste and odor causing algal growths near the surface yet above the higher turbidities and anoxic taste and odors near the bottom.

A water quality evaluation of the alternative terminal reservoir site is summarized in Figure V-17.

Buckhorn Reservoir

From a water quality perspective, Buckhorn is the best terminal reservoir site because it (1) would be filled directly with high quality Mokelumne water, (2) would have a relatively small, undeveloped watershed (6.5 square miles), (3) would be able to be treated at EBMUD's direct filtration plants and (4) would be the deepest (200 to 265 feet at the outlet tower) of the potential reservoirs. The quality of the reservoir would be expected to be similar to that of EBMUD's existing high quality Briones Reservoir (see Figure IV-3).

Pinole Reservoir

Pinole Reservoir would be filled with San Pablo Reservoir water and runoff from 11.4 square miles watershed on which significant agricultural development has occurred. San Pablo Reservoir is filled with Mokelumne water and runoff from a 26 square mile watershed which includes the City of Orinda. Agricultural activities on the Pinole watershed include tomato and hay farming, cattle grazing and horse pasturage. Pinole Reservoir would also be relatively shallow (62 to 89 feet at the outlet tower), about the same depth as San Pablo and Upper San Leandro Reservoirs.

Because of the runoff from urban areas that enter it, and the fact that it is shallow, San Pablo Reservoir is currently subject to persistent taste and odors in the summertime. Since it would be shallow and filled from San Pablo Reservoir and possible agricultural runoff, Pinole Reservoir would also be expected to be subject to persistent taste and odors in the summertime. The quality of the reservoir would be expected to be similar to that of San Pablo Reservoir (see Figure IV-3) and would be treated at Sobrante Filter Plant, a full treatment plant.

Los Vaqueros Reservoir

Los Vaqueros Reservoir could be filled with either Delta water or Sierra sources or both. Its 19 square mile watershed is undeveloped except for cattle grazing. The reservoir would be considerably deeper

Water Quality Evaluation of Terminal Reservoir Sites

Figure V-17

ALTERNATIVE	IMPORTED SOURCE WATER	TYPE OF DEVELOPMENT ON WATERSHED	SIZE OF WATERSHED (square miles)	DEPTH OF RESERVOIR AT OUTLET TOWER (feet)	TREATMENT REQUIREMENTS	ANTICIPATED WATER QUALITY PROBLEMS
BUCKHORN	Direct Mokelumne	None	6.5	200 to 265	Direct filtration	None
PINOLE	San Pablo Reservoir	Pinole — Agriculture San Pablo — Urban	11 26	62 to 89	Full treatment	Taste and odor
LOS VAQUEROS	Delta/Sierra water blend	None	19	190	Full treatment (not compatible with EBMUD treatment facilities)	Taste and odor THMs
		None	19	190	Direct filtration	None

than Pinole Reservoir but shallower than Buckhorn Reservoir.

If any Delta water is used to fill Los Vaqueros Reservoir, the California Department of Health Services would likely require full treatment of the water which is not compatible with EBMUD's direct filtration plants. Based on past experience with Delta water in San Pablo and Upper San Leandro Reservoirs, problems with taste and odors and high THM levels would likely occur.

If Sierra water sources only are used to fill the reservoir then the water would be treatable at EBMUD's direct filtration plants as long as the turbidity in the reservoir due to local runoff from the larger watershed is not excessive.

ALLOCATION OF COSTS AND FINANCING

The allocation of costs for the proposed elements of the Water Supply Management Program is based on how the facilities would be used and whom they would benefit. The following is a brief description of the analysis made to determine the allocation of costs and financing for the projects.

Water Conservation Program

The water conservation program is of benefit to all customers. The program will be financed by an increase in the water rates to all customers. This represents the cost of additional water conservation measures beyond the Base Case measures, which are already in place. Annual cost for the additional measures is estimated to be \$296,000/yr in 1988 dollars, for a total water conservation program cost of about \$600,000 per year. The average increase in a typical monthly water bill would be about \$0.03 for the additional measures. There will be no increase in the System Capacity Charges (SCC) resulting from the water conservation program.

Water Reclamation Projects

In order to keep the price of reclaimed water competitive with potable water, the Water Conservation and Development Fund will be used to finance much of the capital construction. In accordance with the recently adopted policy on the Sale of Reclaimed Water, the price of reclaimed water will generate sufficient revenues which, when combined with connection charge revenues, will recover all District costs to the extent possible without increasing the overall cost to the user. The estimated capital cost for water reclamation projects is \$15 million in 1988 dollars. However, there will be no increase in the water rates or SCC resulting from the implementation of water reclamation projects.

Improvements in the Delta

Levee and foundation improvements, including preliminary engineering, will help ensure the security of the District's water supply system, and this is a benefit to all customers. The cost of this program will be financed by an increase in the water rates to all customers. The estimated capital cost for the program is about \$10 million in 1988 dollars. The money will be raised through the issuance of bonds. The average increase in a typical monthly water bill would be about \$0.11.

Treatment Improvement Program

The treatment improvement program is a comprehensive program planned to assure that water quality will meet future drinking water regulations, to improve the aesthetic qualities of the water, and to improve treatment operations in terms of flexibility, reliability and cost. The program is a benefit to all customers and is being financed by an increase in the water rates to all customers. The estimated cost for the program is about \$35 million in 1988 dollars. The money will be raised through the issue of bonds. The average increase in a typical monthly water bill is about \$0.30.

Protect Existing Sources

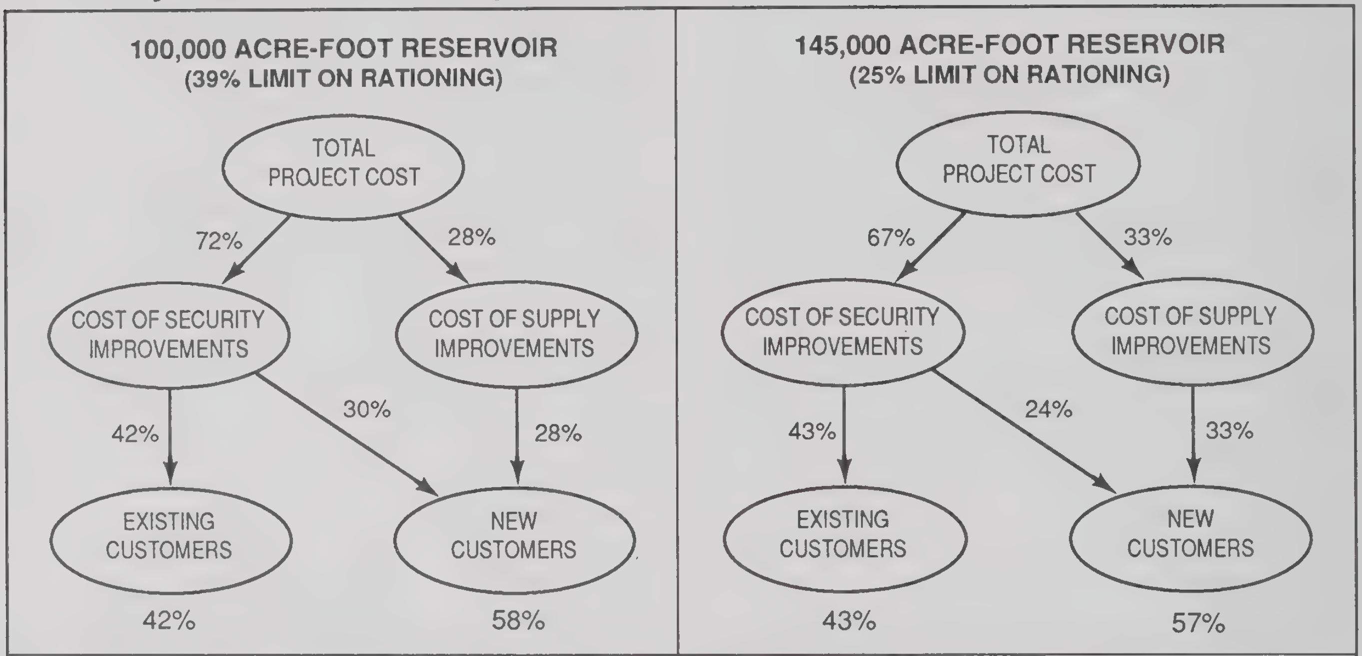
The estimated cost to purchase additional watershed to the ridgelands around the existing and any proposed terminal reservoirs would be about \$20 million in 1988 dollars. The money will be raised through the issuance of bonds. The average increase in a typical monthly water bill would be about \$0.11.

Additional Terminal Storage

A new 145,000 acre-feet reservoir would be used to provide security during extended outages of the water supply and also to accommodate demand increases by providing additional water for regulation, 120 days standby and use during droughts. Security is a benefit to all customers while accommodating future demands is a benefit to new customers. A composite picture of the cost allocation is shown in Figure V-18. Forty-three (43) percent of the cost will be paid for by existing customers through an increase in the water rates. The other 57 percent will be paid for by new customers through an increase in the SCC, although a small portion will come from the water rates paid by those new customers. The estimated cost for Buckhorn Reservoir is about \$152 million in 1988 dollars.

Summary of Terminal Storage Cost Allocation

Figure V-18



The allocation of cost by type of improvement and by customer group depends on the limit on rationing duriring a drought or supply outage, which determines the amount of new storage needed. The existing policy includes a 39% limit on rationing.

About $152 million will be financed through the issuance of bonds.

Figure V-19 shows the increase in rates and SCC needed to finance the reservoir project. The average increase in a typical monthly water bill for existing customers to pay back 43 percent of the bonds for a 145,000 acre-feet Buckhorn Reservoir is about $0.81. The average increase in SCC needed for new customers to pay back the remaining 57 percent of capital cost is about $350 per 100 gpd. The SCC will begin in 1989.

PROPOSED WATER SUPPLY MANAGEMENT PROGRAM

The proposed projects for the Water Supply Management Program are summarized in Figure V-20. The public review process for the Draft Water Supply Management Program and Draft Environmental Impact Report is anticipated during May and June, 1988. In addition to the public comment period, a public hearing and a public meeting will be held to receive comments on the key issues, needs, and Draft EIR. A schedule of the process is included as Figure V-21. Implementation of the proposed projects is anticipated to begin in the latter part of 1988 upon EBMUD's Board of Directors' approval of the Water Supply Management Program. A preliminary implementation schedule is provided as Figure V-22.

Financial Impact of Additional Storage

Figure V-19

	100KAF	145 KAF
Rate impact bond debt life(1)	$0.048/CCF	$0.063/CCF
Rate impact debt life(2) Percent of average monthly water bill	1.3%	1.6%
Average SCC increase(3,4)	$285/100 gpd	$350/100 gpd
Region 1	$855	$1055
Region 2	$990	$1230
Region 3	$990	$1230
Region 4	$990	$1230
Region 5	$1135	$1405
Region 6	$1700	$2110
Region 7	$1990	$2460

(1)CCF is 100 cubic feet or 748 gallons of water.

(2)The average bill is based on a monthly usa of 13 CCF.

(3)The Service Capacity Charge (SCC) depends on the average use per person in an area which varies from 300 gpd in Region 1 to 700 gpd in Region 7.

(4)SCC increase is lower than average in 1989 and higher than average in 2020.

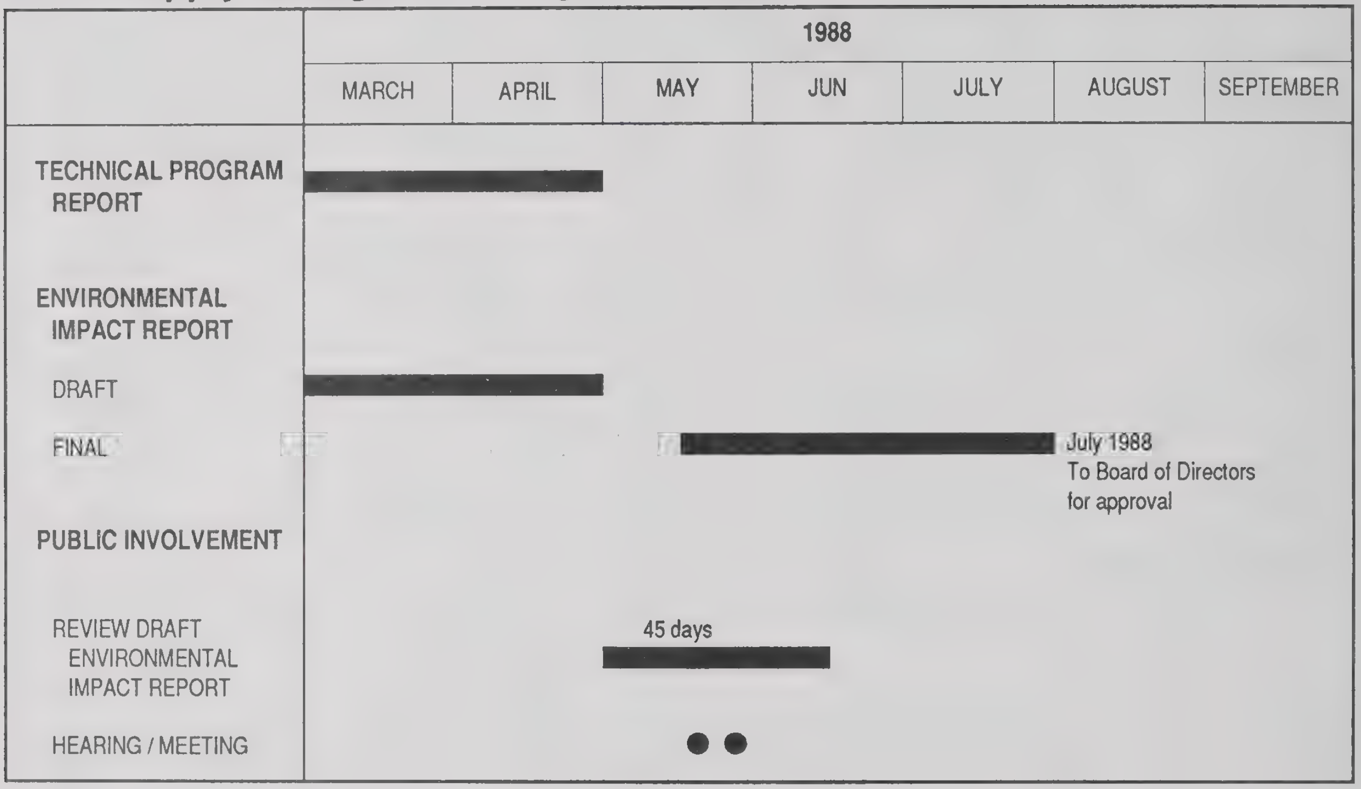
Proposed Water Supply Management Program

Figure V-20

OBJECTIVE	PROGRAM	ACTION	COST	TIMING
SECURITY: Protect against floods and earthquakes	Water Banking (additional terminal storage)	Construct new terminal reservoir (145,000 acre-feet)	$152 to $185 million	In service in 1995
	Levee and Foundation Improvements in the Delta	Continue repair, maintenance and upgrading of levees	$8 million	Complete by 1991
		Preliminary engineering of levee reinforcement and pipeline supports	$2 million	Complete by 1995
SHORTAGE: Supply to meet water demands in dry periods	Water Banking (additional terminal storage)	Construct new terminal reservoir (145,000 acre-feet)	$152 to $185 million	In service in 1995
	Water Conservation	Implement additional measures and continue existing program	$0.6 million per year	Implement immediately
	Water Reclamation	Develop new reclamation projects and continue existing program	$15 million	Implement immediately
SAFETY AND HEALTH: Maintain high quality water	Enhance Watershed Lands of Terminal Reservoirs	Purchase additional watershed lands to the ridgelines	$20 million	Complete by 1995
	Treatment Improvement Program	Continue treatment plant modernization and im-	$35 million	Complete by 1992

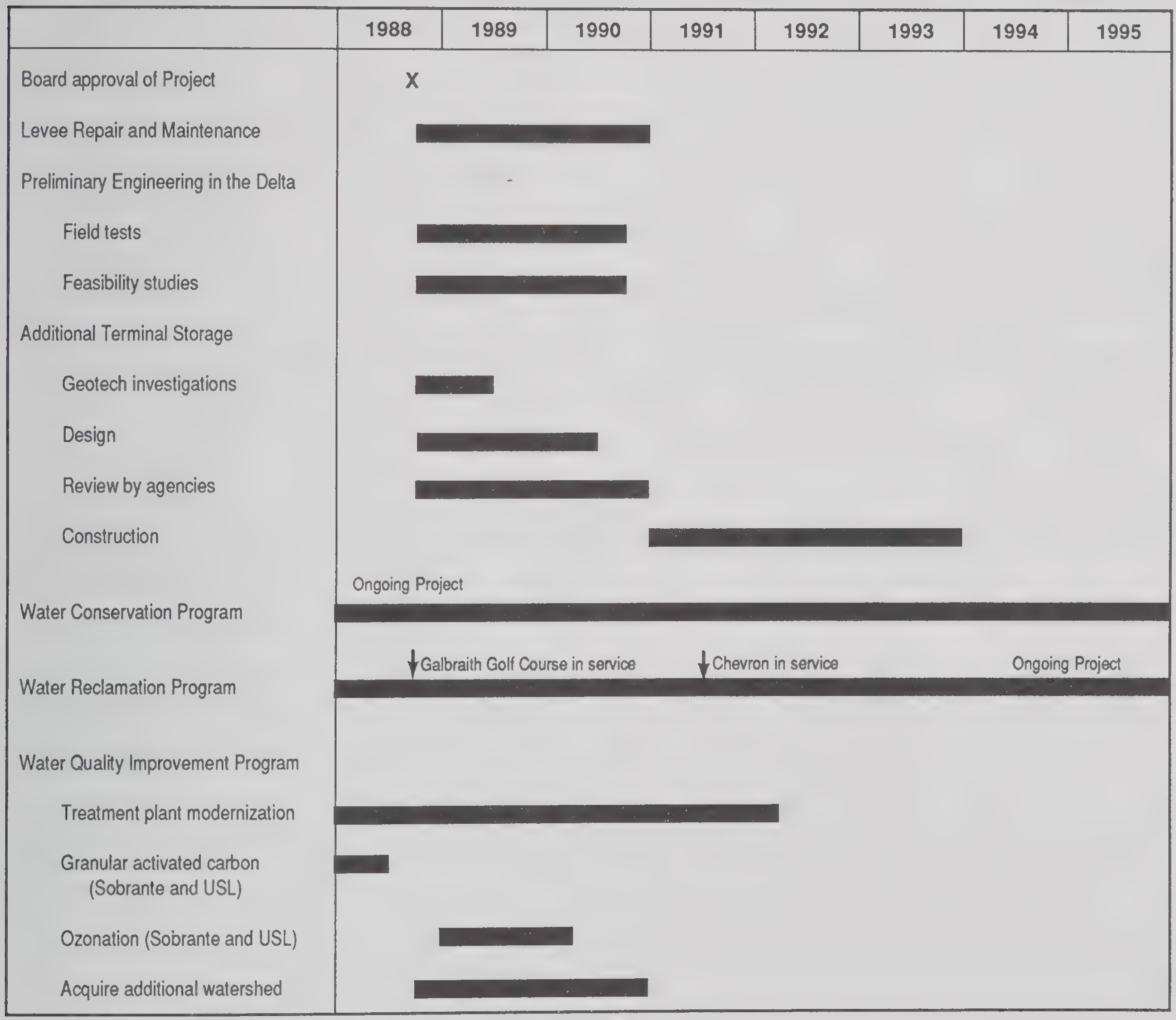
Water Supply Management Program Process

Figure V-21



Water Supply Management Program Implementation Schedule

Figure V-22



Appendix A
Theoretical Water Conservation Measures

This appendix describes water conservation measures evaluated in the development of the Water Supply Management Program which were rejected from further consideration. The reasons for rejecting a measure is included in the discussion of each measure.

Expansion of Leak Detection Program

Currently, the District has two leak detection crews which survey the distribution system with sonic leak detection equipment. Leak detection efforts located approximately 0.5 to 1.5 MGD of leaks each year. The leaks are then repaired or in some instances a section of pipe is replaced. The leak detection program maintains a low (7% to 8%) unaccounted-for water loss rate.

The District could purchase additional leak detection equipment and expand efforts to locate leaks within the distribution system. However, with current staffing levels, the leak detections crews are capable of locating more leaks than the pipeline maintenance crews are able to keep up with. Therefore, to expand this effort would require acquisition of not only leak detection equipment but also additional equipment, and staffing, for pipeline repairs.

Considering that the District's unaccounted-for water loss rate is low by industry standards, and that an increased leak detection effort would require substantial equipment and staffing increases, expansion of this program is not considered feasible or justifiable.

District Installed Water Saving Devices

The District currently plans to distribute about 20,000 retrofit kits per year. The kits include a low flow showerhead, two toilet displacement bags, and dye tables for locating toilet leaks. Approximately one-third of the kits will be distributed door-to-door in selected areas, the others will be available through the District's business offices.

An alternative method of distributing the water saving devices is for the District to offer to install the devices in customers homes. This effort would probably result in more water saving devices being installed and therefore greater water savings. However, the cost to the District to both provide the kits and then install them greatly increases the cost of the program.

In evaluating this measure, it was assumed that 30,000 kits would be distributed each year, and that 75 percent of the kits would be installed (50 percent by District personnel). Furthermore, it was assumed that 15 percent of the devices would be removed, by the customer, after a short period due to dissatisfaction. The estimated annual cost to the District for this program is estimated to be $638,000 per year, five and one-half times the proposed expanded device distribution.

The water saving devices have the potential for saving about 9.8 gpcd (or 23.00 gpd and 17.6 gpd for single and multi-family residential households, respectively in the year 2020). The total water savings in the year 2020 is

projected to be 4.3 MGD. This is an increased of only 2.4 MGD over the current measure and 1.5 MGD over the proposed expanded device distribution.

Other water agencies have installed water saving devices in individual customers homes. However, these efforts have been associated with pilot programs in an attempt to quantify actual water savings of the devices in homes. The high cost of large scale installation of water saving devices in customers homes makes this alternative infeasible. The additional water savings is small in comparison to the increased cost. Therefore, this measure was not considered appropriate for the District's water conservation program.

Advanced Plumbing Code

Current plumbing code requirements in California mandate the installation of low water using fixtures, including showerheads with a maximum of 2.75 gpm and toilets with a maximum of 3.5 gal/flush, in all new construction. Also, any new showerheads or toilets purchased within the State, at hardware or home improvement stores, must conform to these standards. These requirements have been in effect since 1978.

One possible method to save additional water would be to implement an "advanced" plumbing code which would require the installation of 2.0 gpm showerheads, 1.5 gpm toilets, and low water use dishwashers in all new residential construction. This measure would reduce water use in all new residential households by about 10.9 gpd. Estimates indicate that the incremental cost of a new home equipped with these fixtures would be negligible.

If all new single and multi-family residential households in the District's service area conformed to these requirements an estimated 2.1 MGD could be saved in the year 2020. Customers would also realize secondary benefits of energy cost savings due to reduced water heating. These savings would amount to about $11.20 and $8.60 per year for single and multi-family households respectively.

Implementation of advanced plumbing code requirements would be a major consideration. The requirements could be adopted at the State level. This would require legislation that would be supported statewide. However, certain economies of scale may result if the requirements were imposed statewide rather than at the local level. Alternatively, ordinances for an advanced plumbing code could be adopted by the cities and counties within the District's service area and enforced through building inspectors. Also, it may be possible for the District to impose the requirements on new connections as a condition of water service. The actual cost of the advanced plumbing code measure would depend on how the measure would be implemented.

The widespread adoption of an advanced plumbing code would require public support. Mandatory measures to further restrict water use is not warranted at this time. This is due to the fact that the District's water supply problems are associated with infrequent dry periods and not long-term continuous deficiencies. The District's conservation efforts should not mandate restrictive measures when excess water supplies are available a majority of the time.

Because of uncertainties associated with implementation, public acceptance, and enforcement, this measure has not been proposed as part of the District's Water Supply Management Program. Also, since the District has sufficient water supplies in 9 years out of 10, mandatory restrictions on customers water use is not considered appropriate.

System Capacity Charge Discount

To provide an incentive for installing low water using fixtures in new residential developments, the District could offer a discount on the System Capacity Charge (SCC) paid by all applicants for water service. The District would establish criteria whereby developers who install 1.5 gal/flush toilets, 2.0 gpm showerheads, low water using dishwashers and hot water pipe insulation could receive a discount on connection fees.

As a voluntary program it is impossible to determine the level of response to a SCC discount measure. The level of response would depend, partially, upon the amount of the discount. The discount would have to exceed costs associated with the installation of the required materials, as well as, any administrative costs involved in applying for the discount.

It is difficult to assess the response by developers to this type of incentive program. Assuming 10 percent of the new housing units incorporate the water saving fixtures, approximately 0.2 MGD could be saved by the year 2020. The incremental cost of a home built with these fixtures is estimated to be about $400. Assuming a $500

SCC discount would be sufficient to encourage developers to install the fixtures then the annual cost of the program would be about $160,000 per year.

This measure has not been proposed for the District's water conservation program because of the uncertainty in how new customers would respond to the incentive. However, a landscape rebate pilot program has been proposed to test the responsiveness of customers to monetary incentive. The results of that pilot program may indicate that a SCC discount program may be warranted, or at least worth testing with a pilot program. The District will continue to evaluate the feasibility and practicality of this and others measures as more information becomes available.

Voluntary Toilet Replacement

Since 1978, new construction has been required to install toilets which use no more than 3.5 gal/flush. Homes built before 1978 use about 5.5 gal/flush. Toilets are currently available which use no more than 1.5 gal/flush. The District could encourage installation of 1.5 gal/flush toilets in existing single and multi-family homes by offering customers a $50 rebate to customers who purchase and install the toilets. The effect of a rebate on encouraging customers to install the ultra low flow toilets is unknown.

In evaluating this measure, it has been assumed that only those customers who were replacing broken toilets or remodeling a bathroom would consider installing the ultra low flow toilets. Since the cost of the 1.5 gal/flush toilets is comparable to other toilets the $50 rebate would act as an incentive to customers. Because customers would be replacing toilets anyway, and the program would be voluntary, no additional customer costs have been assumed.

The estimated water savings for this measure, assuming 5 percent of the District's customers replace toilets with ultra low flow toilets by 2020, would be 0.8 MGD. This calculation assumes that 80 percent of the toilets installed are in homes built prior to 1978.

To implement the program, customers would have to apply to the District for a rebate, and District personnel would be required to inspect customers' homes to assure installation of the toilets. The District's cost for administering the program and inspecting customers' residences is estimated to be $120,000 per year.

The uncertainties involved with this measure are significant. A toilet rebate program has never before been attempted on a large scale. To achieve a 5 percent response of residential customers by the year 2020 would mean over 900 customers per year would have to accept the rebate offer from the District. A $50 rebate may not be sufficient to influence enough customers for water savings to be significant. The District will test the responsiveness of customers to monetary incentives through the proposed landscape rebate pilot program. The results of the pilot program may indicate that rebate programs are effective in encouraging water conservation.

There is also uncertainty associated with the water savings from the ultra low flush toilets. Customers may not be satisfied with their performance and may decide to place old fixtures back into use. Also double flushing may reduce actual water savings.

Because of the uncertainty associated with this measure, it has not been proposed for the District's water conservation program. Experience gained from the proposed landscape rebate program may provide some insight on the acceptability of rebates as a means of encouraging water savings, and therefore this measure may be considered at some future date.

Mandatory Toilet Replacement Program

In developing the Water Supply Management Program, the District also considered a mandatory measure to force the installation of ultra low flush (1.5 gal/flush) toilets in existing homes. Under this measure the District would require installation of 1.5 gal/flush toilets in all homes at the time of resale. No rebate would be offered to customers by the District. The District would be responsible for compliance by inspections conducted at the time customer accounts were opened.

It is estimated that customers cost for this measure would be about $400 dollars for each toilet (including purchase and installation) replaced in the home. District wide this would amount to an estimated $12,800,000 per year in customers costs. The District's cost for implementing and enforcing this measure is estimated to be $525,000 per year. Projected water savings from this measure in the year 2020 is 14.0 MGD.

While the potential for water savings is significant, it is not know how customers would respond to such a drastic conservation measure when water supplies are more than sufficient most of the time. This measure has recently been imposed in two California communities, however, these communities are also facing severe water shortages. The long-term effect of these measures is not known.

This measure has been rejected from further consideration because of its high cost both to customers and to the District. While theoretically water savings could be significant, such a mandatory action is not considered appropriate for EBMUD since the District's water supplies are sufficient in 9 years out of 10.

Mandatory Toilet Retrofit for Non-Residential Customers

This mandatory measure would require the installation of retrofit devices on toilets in all commercial, institutional, and industrial establishments at the time of resale of the building. The devices consist of inserts which reduce the flow through toilets generally found in commercial buildings.

It is estimated that the cost to non-residential customers would be negligible to retrofit each toilet. The District's cost to inspect buildings when new accounts are opened is estimated to be $15,000 per year. Potential water savings from this measure is projected to be 0.5 MGD in the year 2020.

On the surface this measure seems rather simple to implement. However, administration of the measure could prove to be very difficult. A visual inspection of toilets may not indicate whether they have been retrofitted or not. Customers may not be willing to spend the time or the money on even a simple retrofit procedure. There would also be the question of who would be responsible for the retrofit, the buyer or the seller of the property.

Details on the implementation and administration of the program could be worked out, but it is doubtful that customers would respond positively to such requirements. Since the District's approach towards water conservation has been through voluntary measures, this measure has not been proposed for the District's water conservation program. Furthermore, the inserts used to retrofit toilets will be offered to non-residential customers through the water audit program.

Landscape Rebate

The Water Supply Management Program proposes to determine the effectiveness of offering rebates to customers who install low water landscapes that meet District criteria. A pilot program is necessary since this approach towards encouraging conservation has not been attempted before. A full scale landscape rebate program may be, at some future point in time, an effective conservation measure. However such an approach needs to be tested.

The effectiveness of a landscape rebate program largely depends on the customers response to a monetary incentive. Water savings of 1.3 MGD could be achieved by 2020 if 10 percent of the existing single and multi-family customers reduce outside water use by 25 percent. The monetary incentive necessary to achieve this level of response is unknown.

The pilot program proposes a rebate of $300 per single family household, and $300 per 5,000 square feet of landscaped area for multi-family complexes, to test the response rate of customers to this type of incentive. Higher rebates may actually be needed to encourage a significant level of response. The cost of the rebate program would vary with the amount of the rebate and the level of customer response, and cannot be adequately determined at this time.

The District will continue to evaluate the potential benefits of the landscape rebate program as further data becomes available.

Voluntary Dual Line Plumbing

A dual line plumbing system for residential households consists of independent water lines coming from the bath and shower which go to a filter system. Partially treated water from the filter would then be used for underground irrigation of shrubs and trees, thus reducing landscape irrigation water needs. Under a voluntary approach to this measure the District could encourage the installation of dual plumbing systems in new homes through a discount on connection charges. The discount would have to equal the cost of installing the system to be effective.

Dual line plumbing systems for individual homes are very costly, adding approximately $2,000 to the cost of a home. Furthermore, there are many other factors to consider in operating such a system. A filtration system would require continuous operation and maintenance to assure safe and continued use. There is no assurance that a homeowner would even be willing to use the system.

There are also health concerns with dual line plumbing that would have to be addressed. For example, use of partially treated water on landscaping may be a concern even if applied underground. Excessive application could result in ground saturation and ponding of water on the ground surface.

Even if the cost, public acceptance, and health issues were resolved this program would only save about 0.1 MGD, assuming 5 percent of the new homes built up to the year 2020 included the dual plumbing system. The cost of a voluntary program, with a $2,000 connection fee discount, would be about $235,000 per year.

The low water savings, high cost, public health, and customer acceptance of this measure make it unsuitable for the District's water conservation program.

Mandatory Dual Line Plumbing

The District also considered a mandatory measure to require installation of dual line plumbing systems (as described above) in all new single family homes. This measure would have all the problems of the voluntary measure but the full cost of the dual line plumbing systems would be borne by customers. Since more systems would be installed District-wide, more water would theoretically be saved. However, there would be no assurances that the systems would be used. In fact, installation of the systems would have to allow for non-use of the system by providing a connection to the sewer system.

This measure has also been rejected from further consideration for the same reasons as the voluntary measure, plus a mandatory measure is considered to be too restrictive on customers and inappropriate for the District's water supply situation.

Water Efficient Technology

New commercial, institutional, and industrial customers could be required to employ the latest water saving technology. This would include efficient cooling systems, recycling of process water, and low water using sanitary fixtures. The measure would focus on inside water use.

To implement this measure, the District would establish criteria on water using equipment, processes, and fixtures. The District would then either encourage the cities and counties within the service area to adopt the criteria for use by building officials in granting building permits, or the District may impose the criteria on new customers as a condition of water service.

Assuming that 50 percent of the new customers would be affected by the water efficiency requirements, and that water savings of 10 percent is achieved, then 0.7 MGD may be saved by the year 2020. Assuming the District administers this measure, the District's cost is estimated to be approximately $100,000 per year.

If available water saving technology is also effective in reducing total operational costs then requiring such technology would benefit the customer, and would probably occur without any regulation by the District. However, if regulations would force a business of industry to employ technologies that were not cost effective then the result would be to discourage business from coming to the East Bay area. This ultimately could have an impact on employment and the economy of the East Bay area. The cost to customers for requiring water efficient technologies is uncertain. Also, it would be a difficult task for the District to stay on top of all water saving industrial processes to be able to regulate which processes are water efficient, as well as, cost efficient.

Industrial customers have reduced water use in the past 10 years through process changes. These changes were a response to severe drought conditions in 1976-77 and also economic necessity to remain competitive. It would be inappropriate for the District to mandate water use practices by customers when the restrictions would be counter productive for the customer. If water saving processes are beneficial to the customer they will occur without regulation. Therefore, this measure was not proposed for the District's water conservation program. The District will, however, work with customers, through the water audit program, to assist in identifying water saving practices which could be employed by customers. This would be a much more effective means of encouraging water savings.

Appendix B
Project Costs for Additional Terminal Storage

(Million Dollars - 1988)

ITEM	PINOLE RESERVOIR	
	Spillway 313 ft. (29 KAF)	Spillway 340 ft. (50 KAF)
1) Construction Cost	49.2	54.4
2) Design Engineering and Construction Support	2.8	3.0
3) Contract Administration	1.5	1.6
4) Material Engineering	1.0	1.1
5) Property	0.0	0.0
6) Reservoir Filling	2.4	3.8
TOTAL	56.9	63.9

ITEM	BUCKHORN RESERVOIR	
	Spillway 680 ft. (80 KAF)	Spillway 745 ft. (145 KAF)
1) Construction Cost	94.9	134.1
2) Design Engineering and Construction Support	5.3	7.5
3) Contract Administration	2.9	4.0
4) Material Engineering	1.9	2.7
5) Property	3.5	3.5
6) Reservoir Filling	8.5	17.4
TOTAL	117.0	169.2

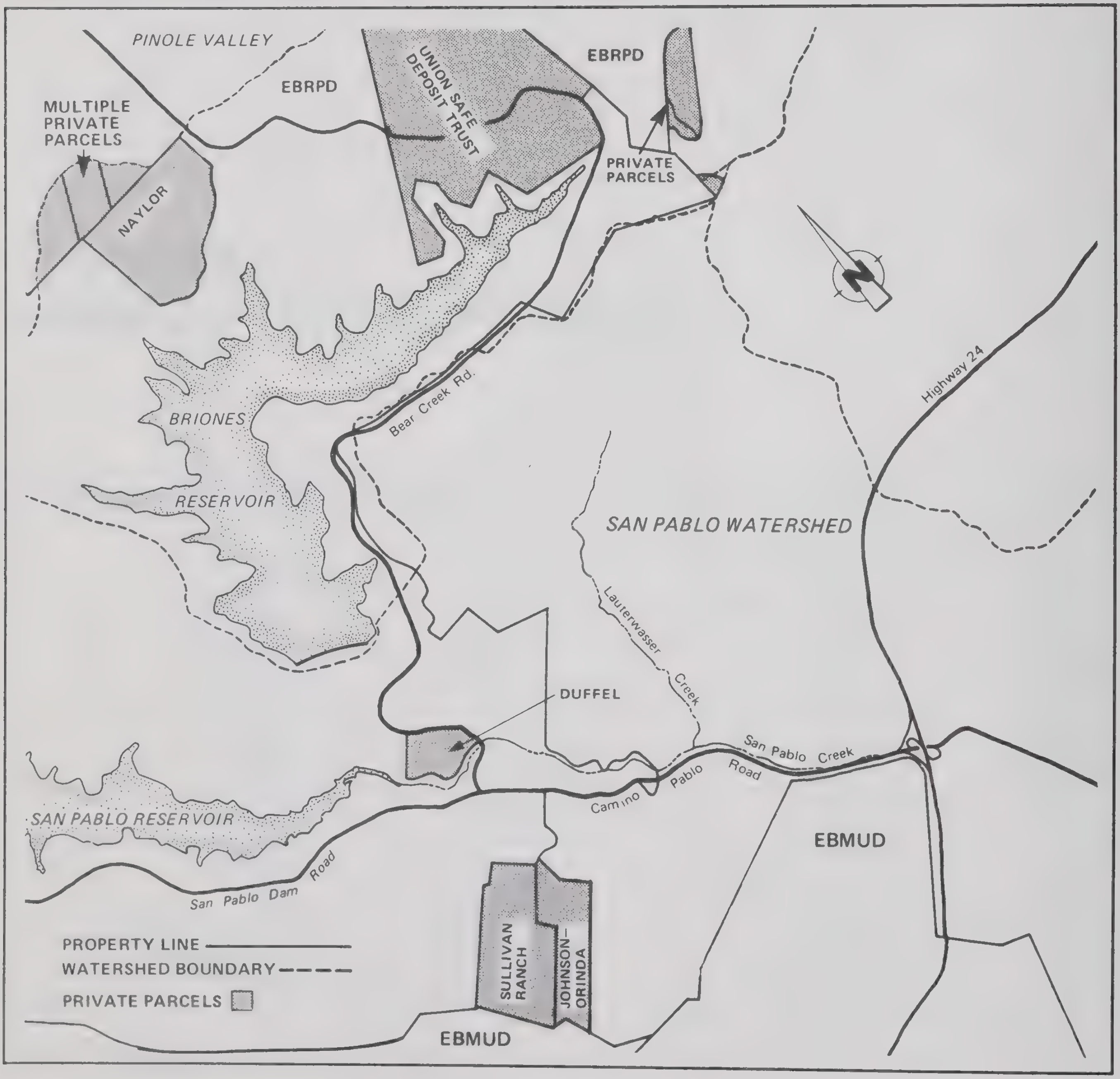
ITEM	LOS VAQUEROS RESERVOIR (EBMUD SHARE ONLY) Spillway 560 ft. (155 KAF)
1) Construction Cost	139.0
2) Design Engineering and Construction Support	13.9
3) Contract Administration	8.3
4) Material Engineering	5.6
5) Property	19.0
6) Reservoir Filling	13.0
TOTAL	198.0

Appendix C
Possible Watershed Acquisition

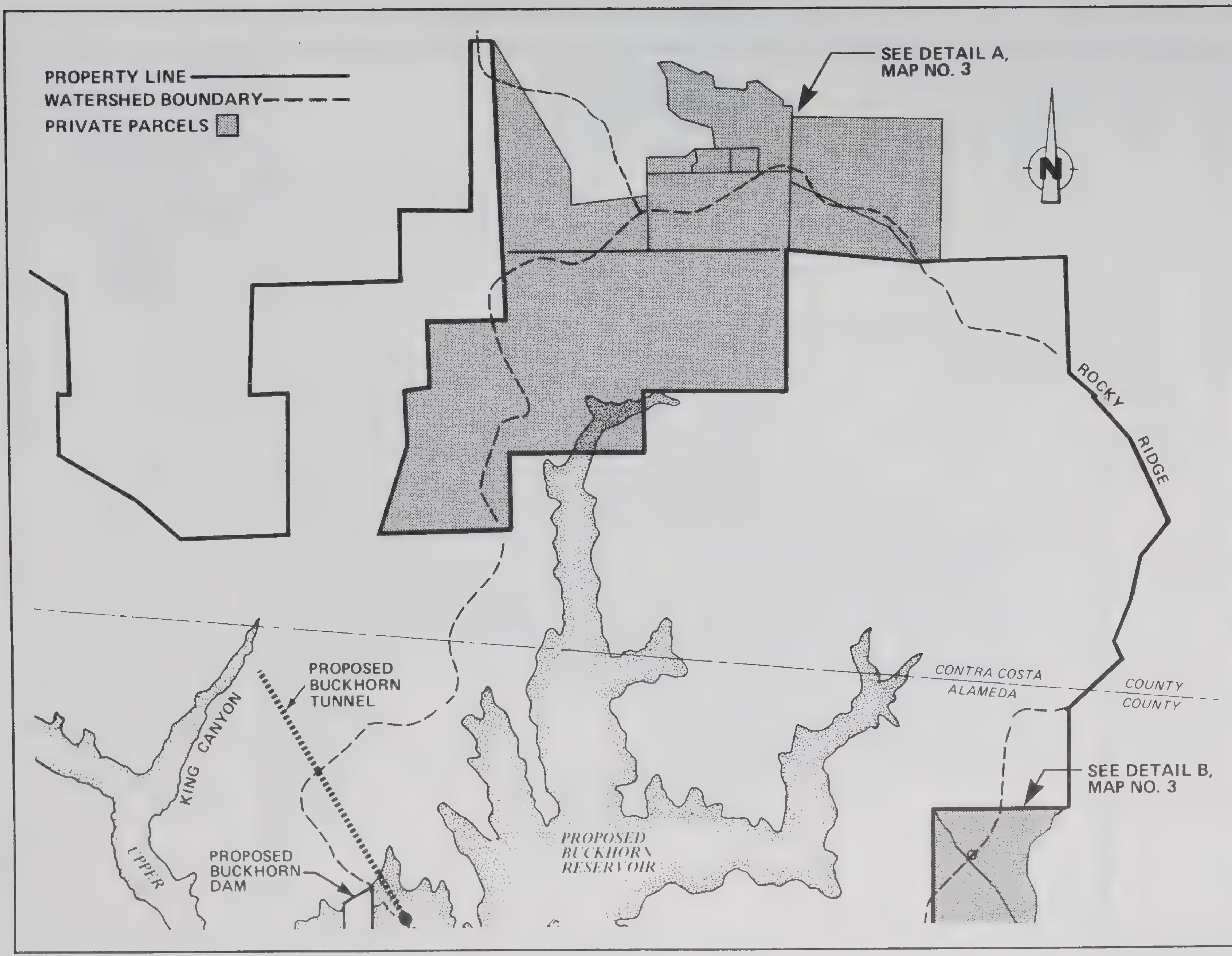
WATERSHED	PARCEL IDENTIFICATION	WATERSHED	PARCEL IDENTIFICATION
Briones	Multiple private parcels	Pinole	Pereira, F.
Briones	Naylor	Pinole	Pereira, F.
Briones	Union Safe Deposit	Pinole	Pereira, F. & J.
Buckhorn	A.J. Carr	Pinole	Pereira, M.
Buckhorn	Alongi	Pinole	Pereira, M.
Buckhorn	Lawrence	Pinole	Pereira, M.
Buckhorn	Morgenthaler	Pinole	Pereira, M.
Buckhorn	Peres	Pinole	Pereira, M.
Buckhorn	Rhoda	Pinole	Santos
Buckhorn	Vanier	Pinole	Saraiva
Pinole	Burg	Pinole	Sears
Pinole	Cunha, A.	Pinole	Soehngen
Pinole	Cunha, M.	Pinole	Watson-Dutra
Pinole	Nunes	Pinole	Westgard
Pinole	Pereira, A. & M.	Pinole	York
Pinole	Pereira, E.	San Pablo	Duffel
Pinole	Pereira, E.	San Pablo	Johnson-Orinda Ranch
Pinole	Pereira, E. & J.	San Pablo	Sullivan Ranch
Pinole	Pereira, F.	Upper San Leandro	Bruzzone

Briones and San Pablo Watersheds (in part)

Map 1

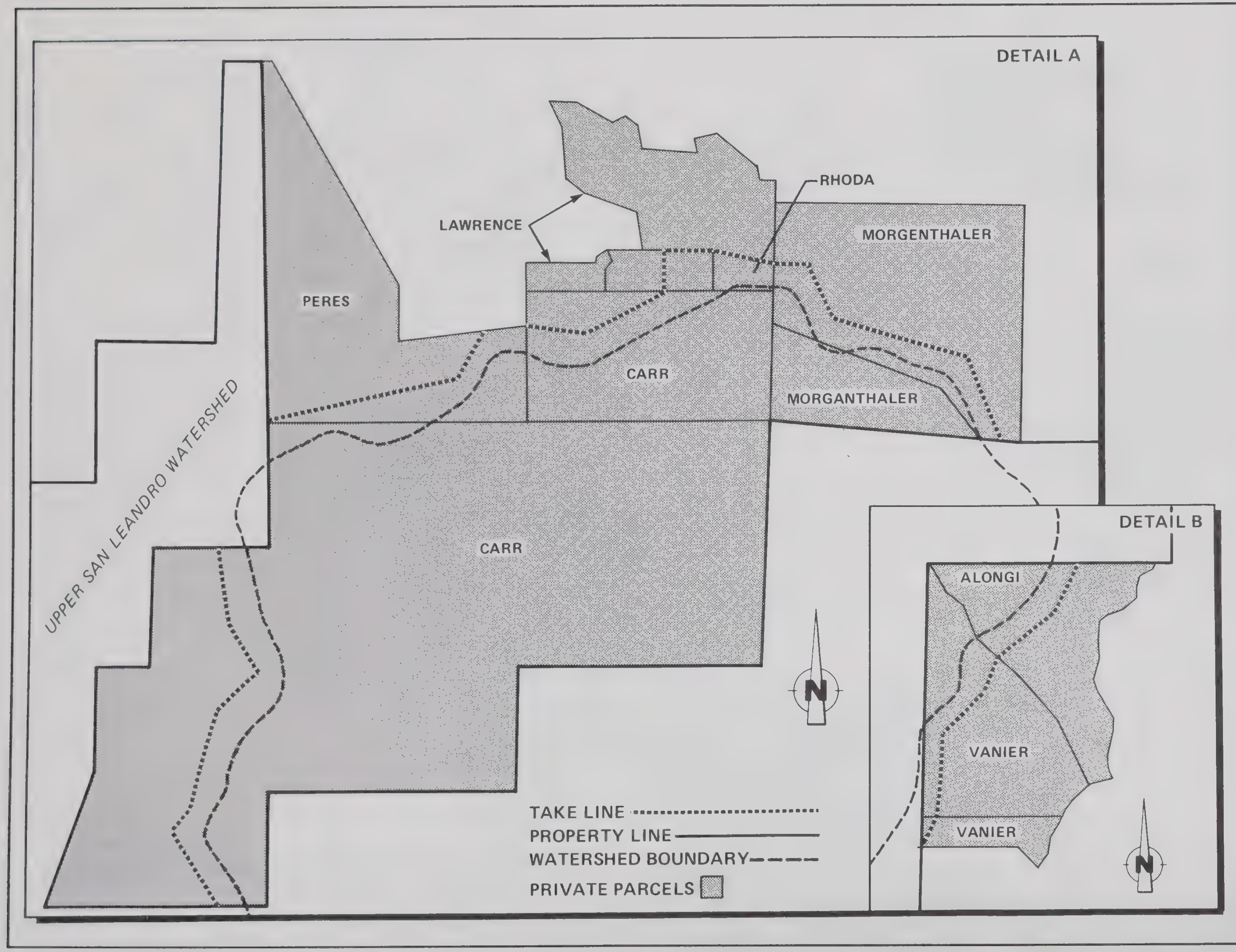


Buckhorn Watershed (in part)



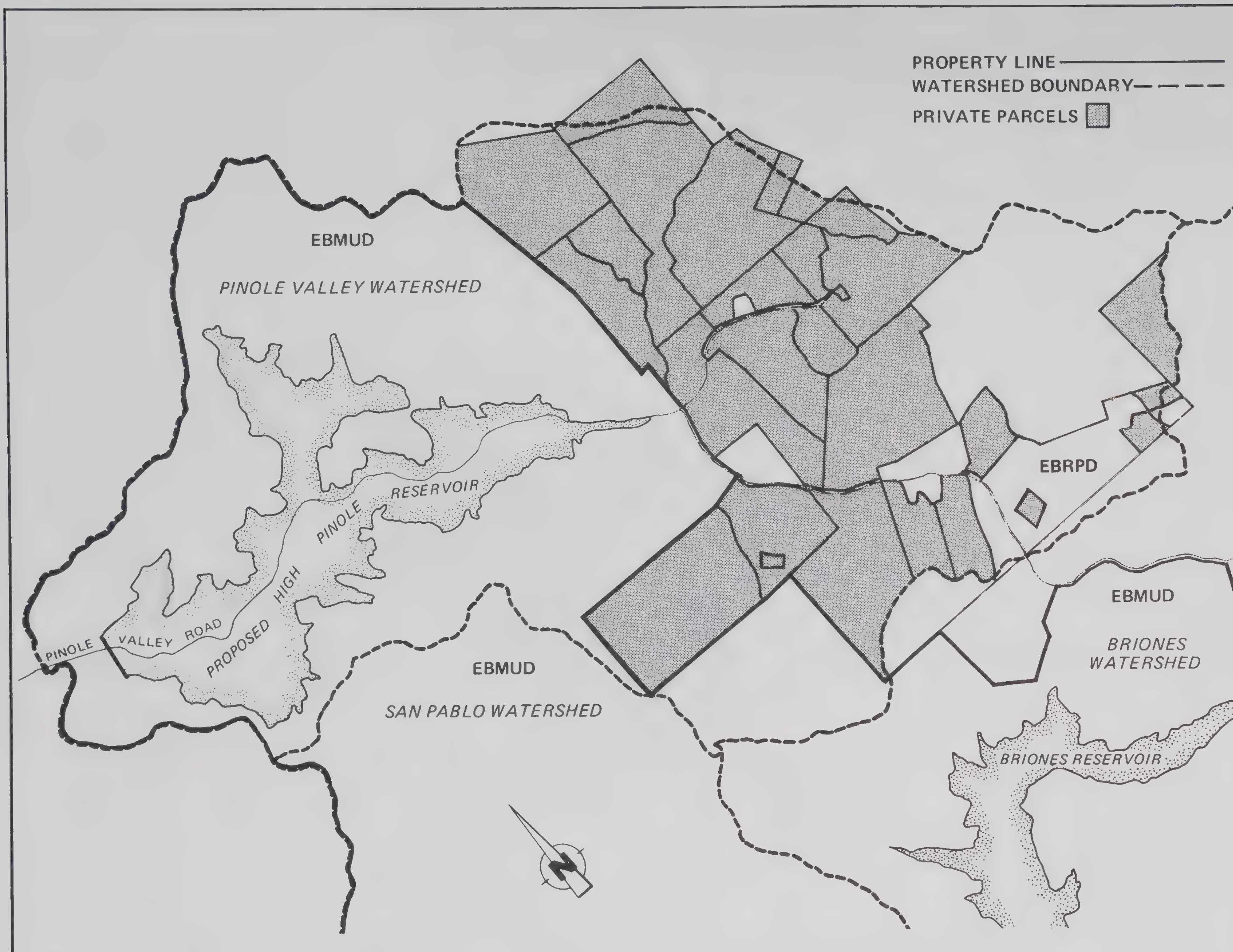
Map 2

Buckhorn Watershed (detail)

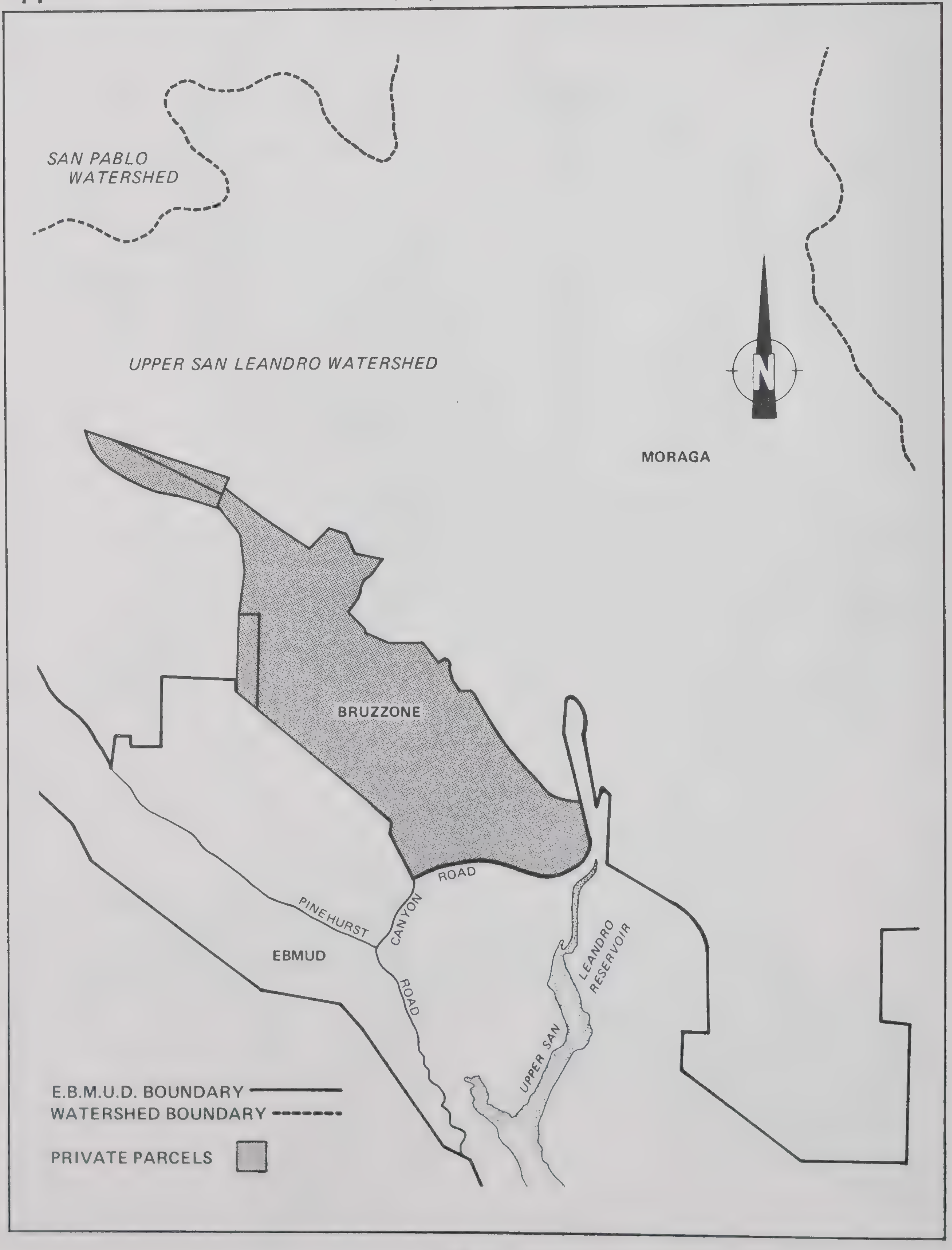


Map 3

Pinole Watershed



Map 4


SAN PABLO WATERSHED
UPPER SAN LEANDRO WATERSHED
MORAGA
N
BRUZZONE
ROAD
PINEHURST
CANYON
EBMUD
ROAD
LEANDRO RESERVOIR
UPPER SAN
E.B.M.U.D. BOUNDARY
WATERSHED BOUNDARY
PRIVATE PARCELS

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Appendix E
Consultant Costs

The Cost incurred by those consultants making direct contributions to this report are listed below.

- William B. Maddaus, Brown and Caldwell, Consulting Engineers
  (Purchase Order No. 510-22957-A, cost not to exceed $10,000)
- Joseph B. Franzini, Professor of Civil Engineering, Stanford University
  (Purchase Order No. 510-23042-A, cost not to exceed $5,000)
- Bernard B. Gordon, Consulting Engineer
  (Purchase Order No. 514-7209AZZ, cost not to exceed $12,500)
- John Boland, Consultant
  (Purchase Order No. 210-20759-A, cost not to exceed $7,500)
- Melissa Blanton, Editor
  (Purchase Order No. 510-23044, cost not to exceed $5,000)
- Thomas Mongan, Editor
  (Purchase Order No. 514-23031, cost not to exceed $13,000)
- Miller-Starr-Regalia, Attorneys at Law
  (Purchase Order No. 510-37301-A, cost not to exceed $19,500)

Costs incurred by other consultants have been cited in other reports previously prepared.